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A NEW THEORY OF THE SURFACE OF MARS*

BY DEAN B. MCLAUGHLIN

OF all the heavenly bodies, Mars probably ranks third in terms of the total man-hours spent by astronomers (both amateur and professional) in studying it. The moon and sun alone claim greater attention. Only three planetary bodies have their solid surfaces open to our detailed inspection: the earth, the moon, and Mars. All three have features that are distinctively their own. Mercury and the large satellites of Jupiter have visible markings, but they are very difficult to observe.

When it is closest, as it was in September 1956, Mars is 35 million miles from the earth. Its diameter, 4,200 miles, only slightly exceeds half that of the earth. In a powerful telescope it appears about as large as an orange held at arm's length. Even the 200-inch telescope, under perfect seeing conditions could not resolve two spots less than four miles apart. Observation of fine details is handicapped by the earth's atmosphere and by limitations of our recording devices. Turbulence in our air causes the image to jump and squirm during a photographic exposure. To catch a tiny fraction of a second of steady seeing, we have to concentrate the light into an image so small that the finest details are lost in the grain of the film. Hence it is that delicate details are best detected by direct visual study under good seeing conditions. The image tube, employing electronic magnification, holds out hope for improved recording, but it is still in the experimental stage.

Even a small telescope shows the three main types of features of the Martian disk. The white polar cap is conspicuous except when it is approaching minimum size. The greater part of the surface can be described as "pastel orange pink", which accounts for the familiar redness of the planet to the unaided eye. About one fourth of the surface is covered by darker markings whose forms at first sight appear irregular. These occupy a belt south of the equator and project in places into the

*Lecture delivered before the Toronto Centre of the Society on April 17, 1956.

northern hemisphere, where one or two isolated dark regions are also found. They present various shades of pastel greenish gray, dark bluish, and even deep purplish or violet gray. Seasonal changes of tint in these regions have often been cited as evidence of the presence of vegetation. From analogy with the moon's dark areas, the name "maria" or "seas" has been adopted, though it has been plain for many years that they cannot be bodies of water.

With higher power one finds a number of smaller dark spots scattered pretty much at random over the reddish "deserts". These are 100 to 200 miles in diameter and are known as "oases". The controversial "canals" are often seen with telescopes of six inches aperture and upwards, but under high magnification with instruments of over 30 inches, they are usually lost. Kuiper (1955) has discussed the canals critically. There are many indications that they represent a merging of fine detail in instruments of too low resolution or under low magnification. High powers separate the details of the pattern and the "canal illusion" is lost. The most extensive series of observations with a telescope of more than 30 inches aperture was made by Antoniadi (1930) with the 33-inch Meudon refractor. Only occasionally did he record a feature that had some resemblance to the ideal "canal". Instead, he saw many of the canals resolved into natural-looking detail. The same result has been obtained by Dollfus (1953) at Pic du Midi. However, this verdict has not received unanimous acceptance.

Mars' atmosphere, area for area, is about one fifth that of the earth. The most dependable measurement of its amount depends upon the polarization of light by atmospheric scattering (Dollfus, 1951). The Martian atmosphere seems peculiarly efficient in scattering violet light, so that we seldom see the surface in photographs taken in the short wave-lengths. The composition of the atmosphere is not directly determinable. There is several times as much carbon dioxide per unit as on the earth (Kuiper, 1949, p. 335; Grandjean and Goody, 1955), but it is still a minor constituent. Water vapour, according to spectroscopic test, is less than 0.2 per cent. of ours, and oxygen is equally scarce (Dunham, 1949). The bulk of the atmosphere is some gas that has no absorption lines in accessible parts of the spectrum. Nitrogen, the main constituent of our air, satisfies this condition and also the requirement of cosmic abundance. Probably argon is present also, since it is a decay product of radioactive potassium. If the production of argon has been the same, area for area, on Mars as on earth, then Mars' atmosphere should be about 5 per cent. argon. The remaining 95 per cent. is probably nitrogen.

Mars is extremely dry. The polar caps are water (Kuiper, 1949, p. 337), but they are probably only inches in thickness. Dust storms have been seen moving slowly, as large yellow clouds, across the planet's face. Occasional whitish clouds, high in the atmosphere, may be composed of ice crystals, like our cirrus. Temperatures at the surface are colder than on the earth (Gifford, 1956), but at perihelion in the tropics, the noon temperature may equal that of a warm spring day. The dark areas are distinctly warmer than the reddish deserts (Strong and Sinton, 1956).

Direct evidence on the nature of the surface material is difficult to obtain. The reddish deserts have been compared to red sandstone and have been likened to the Painted Desert. However, the infra-red reflection does not match that of the iron oxide, hematite, which colours red sandstone. Kuiper (1949, p. 335) found that a brownish felsite, a volcanic rock, gave the best match. In 1937, Peter Millman (1939), then at the David Dunlap Observatory, attempted to test the dark areas for the reflection of chlorophyll, the green colouring material of the leaves of trees and of grasses. Chlorophyll has a strong reflection band in the green and yellow, but Millman found that this was completely absent in light reflected by the "seas". Some years later, Kuiper (1949, p. 339) studied the dark areas in the infra-red, where chlorophyll has another strong reflection band. This test also was wholly negative. However, some forms of vegetation on earth, such as lichens and certain mosses, have only a weak infra-red reflection, so that the observations do not completely rule out all plants. They do rule out our trees and grasses. More than this we cannot say at this time. However, this observation furnishes an example of the way in which wishful thinkers can twist facts. With proper scientific caution Kuiper stated that the observations were "not inconsistent with the presence of lichens". In other words, he could not prove lichens to be *absent*. But this has been distorted by some popular writers into an assertion that the observations prove lichens to be *present*. The most that we can say about the dark markings on the basis of colour is that they have no strongly marked features that identify their material. The greenish tints are for the most part pastel shades, and the violet or purple of the darkest parts is probably due to scattering of light by the Martian atmosphere through which we have to view them.

There is another possible mode of study of Mars that has been neglected. This can be called the morphological approach. The shapes of areas of contrasting colour on the planet's surface may contain clues to their origin. The outlines of features on the earth, for example, often reveal the geologic processes that shaped them.

First, on considering geologic processes as we know them, we find that

Mars' history must have been very different from ours because of the scarcity of water. There are no streams to erode valleys, no lakes or oceans in which sediments can be deposited. Chemical weathering can occur in the presence of carbon dioxide and scant moisture, but what processes of erosion and sedimentation exist? The Martian winds must be the main agents for transportation of material, and this is attested by the well-known dust storms. One other major terrestrial geologic process appears possible, but let us save that for a surprise!

The south tropical belt of "seas" has a distinctly banded appearance (figure 1). Surprisingly, this has received very little mention, though it is plainly displayed in all maps of Mars and is beautifully shown by many photographs. The bands run from south-east to north-west*, so long as they remain south of the equator. But wherever a band crosses for any considerable distance into the northern hemisphere, it curves

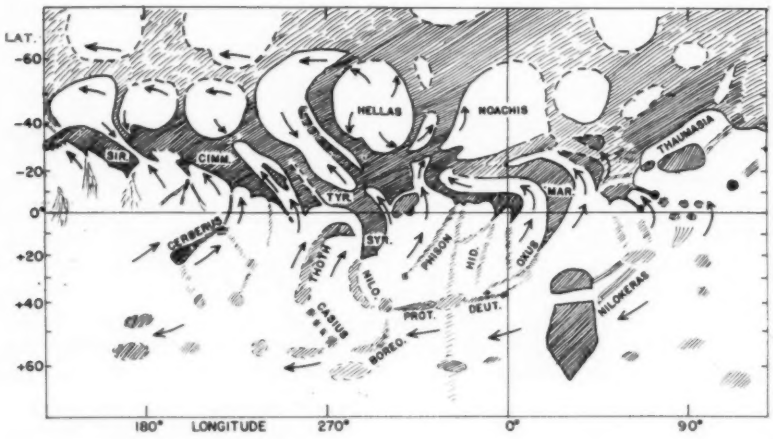

FIG. 1—Sketch map of Mars, based on the map by Antoniadi (*La Planete Mars*, Plates I to IV). Wind arrows indicate the circulation during the southern summer. Obvious abbreviations are used for the following features. *Maria*: Sirenum, Cimmerium, Tyrrhenum, Syrtis Major, Margaritifer Sinus. *Canals*: Boreosyrtis, Deuteronilus, Hiddekel, Protonilus, Nilosyrtis. Dawes' forked bay is at latitude 0°, longitude 0°.

*These directions conform to the conventions of terrestrial maps: with north at the top, east is to the right.

to the north and north-east, and finally ends in a pointed "bay". Such bays are characteristic of the northern "coasts" of the seas that are wholly south of the equator, but the only bays that hook around to the north-east are those that lie north of the equator. Prominent among these are Dawes' forked bay, Margaritifer Sinus, and the giant of all bays, Syrtis Major. Another noticeable orientation is a tendency of the stronger canals in the northern hemisphere to trend north-easterly (Lowell, 1908), though there are conspicuous exceptions.

The south-east trend of the banded seas south of the equator and the north-easterly courses of northern canals resemble a schematic diagram of the trade winds. Recalling that the winds are the most likely agent for transportation of sediment, we can infer that the banding is a pattern of sand or dust that has been drifted by the prevailing winds. Certainly such a pattern of winds is to be expected upon Mars, for air must rise above the areas of maximum solar heating, winds must blow inward to take the place of the rising air masses, and the planet's rotation should deflect the winds in the same manner that our trade winds are deviated. But this does not immediately explain the curving pattern and the pointed bays.

Mars' surface is all land; there are no oceans to stabilize the climatic belts. The strongest heating of the surface will shift north and south with the direct solar rays, and heating will occur rapidly, as it does on terrestrial continents. The wind patterns must shift north and south with the direct solar rays. This means that winds of monsoon type will be produced; they will cross the equator from north to south during the southern summer, and from south to north during the northern summer

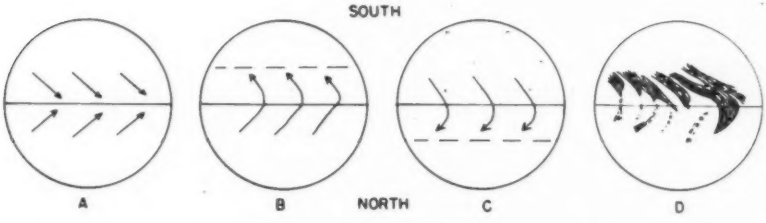

FIG. 2—Wind diagrams compared with the Martian maria. The equator is shown by a heavy line, the "heat equator" by dashed lines. *A*. Normal terrestrial trade winds (schematic). *B*. Martian winds during the southern hemisphere's summer. *C*. Martian winds during the southern hemisphere's winter. *D*. Schematic pattern of Martian maria from Syrtis Major (*right*) to Mare Sirenum (*left*).

(figure 2). As they cross the equator, the rotation of the planet will cause them to curve, just as the south-west monsoon winds of India are curved on crossing the equator. Looking at the Martian map (figure 1), we see vividly presented a flow pattern of dust of different colours carried by the winds. The banded pattern is strong south of the equator because the winds are strongest in the southern summer, when Mars is nearest the sun. The winds of the northern summer must be much weaker, what with less solar heating, and they cannot erase the pattern of dust deposited in the opposite season.

Now we see that the pointed bays have a very special significance. They must be the sources of the dark dust that is spread out downwind in long trails to form the banded pattern. In our terrestrial experience there is only one way in which a tiny point source can furnish so much dust. We therefore infer that the points of the bays are the sites of active volcanoes that erupt large amounts of ash into the atmosphere, to be carried by the winds and deposited in the fall-out pattern that we see (McLaughlin, 1954a-b). Long-distance transportation of volcanic dust is well established on the earth. Ash from Vesuvius has fallen in appreciable amounts hundreds of miles away (Phillips, 1869).

It has been known for many years that canals extend from pointed bays into the "deserts". The meaning of this now becomes clear. The canals are the weaker trails of ash deposited during the opposite season by the weaker reversed winds. Antoniadi even drew some of the canals in the form of fanned-out smudges, just the sort of feature we would expect if the winds carried the ash of the same volcanoes off over the light deserts.

The volcanic hypothesis also explains some striking changes (McLaughlin, 1955a-b) that formerly have been puzzling. The observations have been discussed by Antoniadi (1930, pp. 131, 141, 194). About 1800, a great horn-shaped dark marking, a twin to the Syrtis Major, crossed the equator to join Mare Cimmerium. Its curvature was consistent with the expected rotational deflection of the winds. It can be interpreted as an ash fall-out from a great eruption at the oasis, Pambotis Lacus. Since then, desert dust has covered it over. In the Solis Lacus region in 1877 a dark horn curved from Phoenicis Lacus towards the south, and it has since disappeared (figure 3). In 1926 the Solis Lacus was distorted by a dark marking that fanned out from a small oasis, Ius Lacus. This marking, too, is no longer visible. These changes apparently represent great explosive eruptions followed by quiescence. The most remarkable feature is that in every case the curvature of the marking agreed with that of winds deflected by the planet's rotation.

Another type of evidence has recently come to light. In 1954, dense

cloud knots formed repeatedly in a very limited area (Pettit and Richardson, 1955). A dense cloud close to the same position was photographed by O. H. Truman with the 100-inch telescope in 1941. In 1939, clouds occurred in the same area (Wright, 1939). And as far back as 1926 a spectacular cloud knot (Wright, 1927) formed in a location that agreed very closely with that of the cloud of 1954. If clouds form recurrently over the same area of the planet, they must be caused by some mechanism associated with a surface feature. One possibility is condensation of steam from volcanic vents. That this may be the nature of the recurring clouds is suggested further by the precise area that is afflicted with clouds: the strongest knot was very close to Phoenicis Lacus, the oasis from which the temporary marking of 1877 fanned out, and parts of the clouds were close to the source of the 1926 marking! This area will surely repay future careful study.

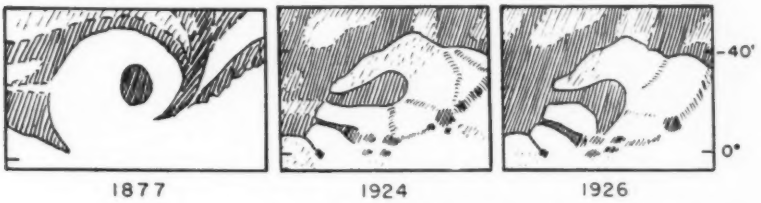

FIG. 3—Changes in the Solis Lacus region, sketched from drawings by Trouvelot (1877) and Antoniadi (1924 and 1926). Phoenicis Lacus is the oasis at the lower right in the sketches for 1924 and 1926.

If the forms of the dark areas are due to fall-out of ash and if the dark colour is that of the ash, then what becomes of the Martian "vegetation"? It is farthest from my intention to deny categorically that vegetation exists on Mars. There is no observed phenomenon that fully convinces me of its presence, but its absence is not proven. When we recall how the Italian vineyard growers plant their vines on the slopes of Vesuvius, to benefit from the fertile volcanic soil, even at the risk of being wiped out by the next eruption, it seems just possible that the areas of ash fall on Mars may be the only places able to support even primitive plants. The seasonal changes may or may not be due in part to vegetation, but if they are, perhaps the forms of the areas where it can grow are determined by the fall-out pattern of the ash and the precious moisture that accompanies it.

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WALTER SYDNEY ADAMS

By C. A. Chant

This internationally famous astronomer died at his home in Pasadena, California, on May 5th, 1956. He was born in Antioch, Syria, on Dec. 20th, 1876, of American missionary parents. Thus he was in his 79th year.

Adams graduated from Dartmouth College in New Hampshire in 1898. In the year 1892, George Ellery Hale was appointed Associate Professor of Astrophysics in the University of Chicago and at once began the organization of the Yerkes Observatory, of which he was Director until 1904. Adams studied at Chicago 1899–1900 and at Munich in Germany in 1901. After this for three years he was Assistant and Instructor in the Yerkes Observatory.

In 1904, Hale organized the Mount Wilson Observatory as a division of the Carnegie Institution of Washington. Of it, he was its Director until 1923, when he became Honorary Director. Adams was Assistant-Astronomer at Mount Wilson 1904–1909 when he was made Astronomer and Acting-Director which position he held 1910–1923 and then he became Director.

The glass disk for the 100-inch mirror was built up by three successive pourings, and it was considered unsatisfactory; but a better one not being obtainable, it was ground and polished and placed in its mounting which had been awaiting it some years. By skilful operation, photographs of the heavenly bodies were obtained of the highest quality. In all this work, Adams was a member of the observatory council and was very helpful. He also helped to plan and instal the 200–inch telescope on nearby Palomar Mountain.

When this great instrument was proposed, an effort was made to determine the best material to use in making the mirror. Fused quartz, with its very low coefficient of expansion by heat, was considered ideal and long and expensive experiments were made to secure a large disk from it, but without success. Then the Corning Glass Company was asked to undertake the production of the disk from low-expansion glass. After preliminary researches, the most suitable procedure to follow was decided upon and some smaller disks were successfully produced.

In September 1932, the fourth meeting of the International Astronomical Union was held at Harvard University, Cambridge, Mass., and at the banquet at its close—I found myself sitting next to Walter Adams. Just at that time, the contract for the Administration Building of the

David Dunlap Observatory had been let and its corner stone was to be laid the very next day; and the contract for the 74-inch telescope had been awarded some years earlier. The great project was proceeding satisfactorily, except for the great disk for the mirror. All efforts to cast it had been failures. Also, Sir Charles Parsons, who personally controlled the Grubb-Parsons firm, which had undertaken to produce the entire telescope, had died on a trip to the West Indies. I told Adams that I had learned that the Corning Glass Company had undertaken to produce the disk for the 200-inch mirror. I asked him if he and his colleagues in California would have any objection to my writing to Corning to ask if the firm would be willing to consider the production of a disk for our observatory. He assured me they would cordially favour it. He said he would be in Corning in a few days and he would urge the Company to help us in any possible way.

I shall not give details of the negotiations. The 76-inch disk was poured on June 21st, 1933. It was taken from the mould at the end of September, tested with polarized light and approved. It was shipped to Montreal and put on the same vessel which had brought the mounting for the telescope to Canada. It was delivered to Newcastle-on-Tyne, where it was put on the grinding-table. After overcoming many difficulties, it was declared finished. A member of our staff went to England and rigidly tested the figure of the mirror which he found to be satisfactory. Then it was packed in its massive case and shipped to Canada. Finally, it was installed in the mounting, which was ready to receive it, and the great telescope was in operation before the official opening of the David Dunlap Observatory on May 31st, 1935.

Adams's researches were numerous and important. Often his clearly announced results brought significant advances in accepted theories. In 1908, by means of the spectrograph, he determined the rotation-period of the sun. Experiments of this sort had been made before this, but the precise law of the variation at different latitudes was given by Adams with peculiar completeness. He also made decisive observations on Mars and Venus.

In 1925, his contribution to our knowledge of the faint companion to Sirius gave remarkable confirmation to the Einstein Theory and the ionization theory of matter.

Adams was President of the American Astronomical Society 1931–34. He received medals from the National Academy of Sciences, the Royal Astronomical Society (London), the Société Astronomique de France and the French Academy of Science.

Surviving him are his widow and two sons.

CANADIAN SCIENTISTS REPORT

II. A SEARCH FOR ANALOGIES BETWEEN LUNAR AND TERRESTRIAL TOPOGRAPHY ON PHOTOGRAPHS OF THE CANADIAN SHIELD, PART I*

By C. S. Beals, G. M. Ferguson and A. Landau

Abstract

Attention is drawn to the correlations between lunar craters and terrestrial meteorite craters and evidence is reviewed attributing to them similar origins.

Previous discoveries of Canadian craters in Quebec, Labrador and Ontario are discussed and the suggestion is made that a search in Canadian Shield areas might well yield further examples.

A study of Canadian aerial photographs has revealed nine craters or crater-like objects. Four of these are tentatively attributed to volcanic action and it is suggested that the remaining five may have been due to meteorite impact. Two of the craters have been found filled with Palaeozoic sediments.

Introduction

Both visual and photographic observations of the moon's surface indicate that lunar topography is dominated by circular features ranging in diameter from a few thousand yards to several hundred miles in diameter. The features of small and intermediate size (up to 150 miles in diameter) are designated as craters, using the generic significance of the word "crater" as a cup-shaped depression with or without raised edges and regardless of physical origin. The larger circular features are called maria or seas because they were so designated by the earlier observers who thought that their dark colour indicated the presence of water. The name has persisted even though it is now reasonably certain that there is no water on the moon.

All students of astronomy are familiar with the general characteristics of lunar craters. They are circular depressions of considerable depth with raised edges. The central part of the crater dips below while the rim of the crater is raised above the surrounding plain. The slope of the inner is much steeper than that of the outer walls. The craters of small

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and moderate size appear deeper than the larger ones, but this is an illusion caused by the fact that the ratio, depth to diameter is greater for the smaller objects. Actually there is a regular though non-linear increase of depth with diameter. A conspicuous feature of many craters is a central peak or mountain, usually of irregular form. The central peak is lower than the rim and does not ordinarily rise above the level of the surrounding plain. The sizes of the craters vary from a fraction of a mile to 150 miles in diameter. The maria are much larger than the craters, being of the order of several hundred miles in diameter. They are circular and at least in part surrounded by rocky walls. In general the circular walls are not complete and it appears that the maria have encroached one upon the other, interfering with the symmetry of their boundaries. Numerous craters located within the maria are partially obliterated being apparently filled up with whatever substance (presumably lava) that originally formed the seas.

The interpretation of the moon's circular features has been strongly influenced by analogies with earthly topography. Although it has been recognized as a possibility that there may be some process peculiar to the moon producing the craters and maria, most investigators have concluded that a solution of the problem is more likely to be found by looking for circular features on the earth which may correspond to those on the moon.

It is impossible to say who first put forward the opinion that the lunar craters were extinct volcanoes, but it was generally current in the 19th century and was considered to receive strong support from the massive observational work of Beer and Mädler (1837) on the features of the lunar surface.

In all probability there has been or is now some volcanic activity on the moon but as time has gone on it has gradually become clear that there is no really satisfactory correlation between the contours of most lunar craters and those of terrestrial volcanoes. For example the outer slope of the surrounding walls of volcanic cones is very much steeper than on lunar craters. Also, the ratio of inner diameter to height above the surrounding plain is very much smaller for volcanoes than for the supposedly corresponding lunar features. There are other equally important differences and the lack of correlation is so fundamental that it is now considered very improbable that the great majority of conspicuous lunar craters are due to ordinary volcanic action.* As a consequence, a number

*Calderas are sometimes quite similar to lunar craters, but the random distribution of the lunar features together with certain details of their structure appears to favour an origin by impact and explosion rather than primary volcanism.

of other theories have been proposed involving various forms of igneous, mechanical and even biological activity. Included among these theories is the suggestion that the majority of the circular features on the moon, including even the great maria, are due to the impact of giant meteorites. This theory, which dates back to the latter part of the 19th century, remained largely a matter for academic discussion until the actual discovery on the earth of a number of circular features which owed their origin to falls of large meteorites.

Early Discoveries of Terrestrial Meteorite Craters

Although it had been known for centuries that meteorites of considerable size sometimes fell to the surface of the earth, the idea that such events could be of sufficient magnitude to give rise to major topographic features was first made definite with the discovery by Barringer (1906) of the great meteorite crater of Northern Arizona. Barringer's hypothesis of meteoritic origin was ridiculed when he first put it forward but subsequent studies have made it clear that the crater was formed by the fall of a large meteorite. Not only has the Barringer crater been shown beyond reasonable doubt to be due to meteoritic impact or explosion, but it has stimulated the search for similar features in other parts of the world. Meteorite craters of generally similar character but smaller size have been found in the United States (Baldwin, 1949), Australia (Alderman, 1932; Madigan, 1937), Argentina (Spencer, 1933; Watson, 1941), Esthonia (Baldwin, 1949), Arabia (Philby, 1933), and Russia (Kulik, 1937). In addition to those craters which show definite proof of meteorite origin, numerous other features have been found which may be due to this cause but for which definite proof is lacking.

These discoveries and their relation to lunar topography have been discussed in detail by Baldwin (1949), Kuiper (1954), Urey (1952), and others. Baldwin has shown that the contours of the Barringer crater and those of other similar terrestrial craters correspond so closely with features of comparable size on the moon's surface as to suggest a common origin. Baldwin has further drawn attention to the fact that craters formed by the explosion of bombs or other large explosive charges show evidence of similarity to meteorite craters. He has combined the data from bomb craters, meteorite craters and lunar craters in a single curve in which logarithm of the depth (from rim to bottom) is plotted against logarithm of the diameter (of top of rim). This curve shows that the three types of craters form a single sequence in which the lunar craters and the bomb craters form the upper and lower ends respectively while the known meteorite craters sit closely on the curve

in its central portion. Actually the bomb craters and the meteorite craters overlap in the lower part of the curve while the recently-discovered New Quebec crater and a new North African crater (Karpoff, 1953) are of sufficient dimensions to overlap the lunar craters in the upper portion of the curve. Baldwin concludes that these data represent strong evidence if not final proof that the lunar craters were formed as a result of meteorite impact.

The terrestrial craters discussed by Baldwin in this connection are all of recent geological age and as he himself points out, a major lacuna in the data is the lack of ancient or fossil meteorite craters corresponding to earlier periods in the history of the earth-moon system. Boon and Albritton (1937) have suggested that this gap may be filled by a meteoritic interpretation of cryptovolcanic structures, an interesting hypothesis but one which must be regarded as still in the speculative stage. New evidence of a different kind is provided by some recently-discovered Canadian craters, more than one of which is associated with a very early geological epoch.

Recently-Discovered Canadian Craters

(1) *New Quebec or Chubb Crater*—Lat. 61° 17′ N., Long. 73° 41′ W.

Canadian interest in meteorite craters has been greatly stimulated by the discovery of the New Quebec crater, otherwise known as the Chubb crater, in the northern part of Quebec Province. This crater, of 2.1 miles diameter was observed on aerial photographs as early as 1945 but the major credit for its discovery belongs to V. B. Meen (1950, 1952) who organized expeditions to examine it in 1950 and 1951 and considered, on the basis of its general similarity to the Barringer crater and the lack of any other acceptable hypothesis of origin, that it was produced by the fall of a large meteorite. Meen's hypothesis received important confirmation from the work of Millman (1955) who made a detailed study of a map of the crater contours derived by the Surveys and Mapping Branch of the Department of Mines and Technical Surveys from aerial photographs. Making use of these contours, together with the depth of the crater lake published by Meen, Millman demonstrated that this new feature showed a profile remarkably similar to that of the Barringer crater and from this he concluded that the hypothesis of meteoritic origin was probably correct. Some important additional facts concerning this crater were presented by Harrison (1954) of the Geological Survey of Canada who showed that the rim of the crater and its surroundings had been heavily glaciated causing substantial erosion and, in all probability, removing any meteoritic material which might have fallen outside the crater depression.

(2) *Labrador Crater*—Lat. 58° 03′ N., Long. 64° 03′ W.

On May 24, 1954, an account of the finding of a small crater of possible meteoritic origin appeared in the columns of the *Toronto Globe and Mail* as well as other newspapers in Canada and the United States. This crater was reported as 175 yards in diameter and the photograph accompanying the article showed a beautiful small lake of almost perfect circular form with the kind of raised edges usually associated with a meteorite or lunar type crater. According to the newspaper account this crater was first photographed from the air by Col. Arthur Merewether of the U.S. Air Force during the second world war and the information was later communicated to Dr. V. B. Meen of the Royal Ontario Museum as a consequence of his work on the New Quebec or Chubb crater. Dr. Meen led an expedition to examine the crater in 1953 and again in 1954. He has not yet given an extended account of his findings but in the newspaper article mentioned above Dr. Meen is quoted as saying in connection with his 1953 expedition "There was no time for extensive exploration because the weather was closing in, but from all appearances this crater must be listed as of suspected meteoritic origin". All astronomers and other scientists interested in crater problems will await with interest Dr. Meen's account of his 1954 expedition.

(3) *Brent Crater*—Lat. 46° 4.5′ N., Long. 78° 29.5′ W.

Subsequently to the discovery of the New Quebec Crater, in 1951, the attention of Dominion Observatory officials was drawn to a circular topographic feature which appeared on aerial photographs of the northern part of Algonquin Park near Brent, Ontario. Examination of the photographs with a stereoscope indicated that the circular area constituted a relatively shallow depression partly occupied by two lakes, Gilmour and Tecumseh, which with their tributary streams outlined a considerable part of the boundary. The area is drained by a small stream flowing out of Gilmour Lake toward the south-west. A comparison of the photographs with large-scale maps of the region gave a diameter to the circle of 1.8 miles indicating that this feature was comparable in size with the New Quebec Crater. Gravity, seismic and magnetic observations by Dominion Observatory scientists (Innes, Willmore and Clark, 1954) and geological studies by the Geological Survey of Canada indicated that this is a crater of many hundred feet in depth filled with Palaeozoic sediments. What has been interpreted as explosion breccia has been found both near the surface and at depth near the rim of the crater. Investigations of the origin of this crater are still in progress. The possibility that it may have been due to a meteorite fall is being seriously considered

and the results of the work will be reported upon elsewhere at a later time.

Regardless of what the final conclusions may be, two aspects of this discovery are of exceptional interest. First, although lumbering and mining operations had been carried on for many years in and around the boundaries of the crater it remained undiscovered until detected on aerial photographs. Secondly, the identification of Ordovician fossils in the sediments filling the crater indicates a minimum age of the order of 400,000,000 years. It thus appears that events capable of causing major depressions of this kind have been occurring over a very long period of time and have probably resulted in the formation of many craters. While it might reasonably be expected that a majority of such features would have been destroyed or obliterated by erosion or the deposition of sediments, a proportion may have survived and retained their circular outlines to a sufficient extent to make it possible to see them on photographs taken from the air. It was accordingly decided to begin a systematic study of Canadian aerial photographs in the hope of discovering additional features of this kind.

General Considerations Concerning a Search for Terrestrial Craters

(a) *Frequency of formation.* In carrying out a search for craters on the earth's surface an important consideration concerns the type of object most likely to be encountered. Since we are looking for lunar correlations it is normal to expect features of a size most numerous on the moon. Unfortunately, statistics are complete only for craters of moderate and large size and no definitive lists exist of the smaller pits or craterlets. Baldwin states that there are many thousands or even hundreds of thousands of tiny craters at the limit of telescopic vision. Kuiper in a private communication has confirmed the fact that smaller craters are very numerous on the moon. On the basis of a study of Mount Wilson photographs as well as by direct visual observation with the 82-inch Texas telescope he reports 100 craters on the floor of Ptolemy and 500 in Mare Serenitatis. These small craters are of the order of ½ mile to 2 miles in diameter. It would appear reasonable to suppose that on the earth also it would be the smaller craters which would be produced in much greater numbers than the larger objects and this probability must be given its due importance in conducting a search.

(b) *Changes or obliteration of craters.* In the absence of water on the moon the type of erosion and deposition common on earth will not be operative. No doubt some erosion caused by heating and cooling and by

bombardment by small meteorites will be present and will eventually have an effect on the older features. There is reason to suppose that many lunar craters have been obliterated by lava flows while the superposition of one crater upon another has obviously affected some features now visible and probably has obliterated others.

In spite of the agencies which are undoubtedly operative in changing lunar topography it would appear that a crater, regardless of its size, has an enormously greater chance of surviving on the moon than on the earth. There can be no question but that the effects of running water, the action of waves, the movement of glaciers, the blowing of sand, the penetration and subsequent freezing of water into cracks, the effects of biological organisms and the deposition of sediments would cause the disappearance of most terrestrial craters in a geologically short space of time. It is by no means certain which size of object would suffer most and be most quickly eroded down and filled in. No doubt very small pits would quickly disappear. It would appear reasonable to suppose that the larger the structure the longer at least some vestiges of it would remain. However, the very great numbers of craters of the order of a mile in diameter would likely have their effect and it is probable that here and there in widely separated areas, some special circumstances would have operated to preserve at least the circular outline if not the entire structure of features of this size. The possibility should be borne in mind that such a "fossil" crater might be so changed as to deceive the observer and all circular or partly circular features should be carefully studied even though they may at first show little similarity to lunar features. The possibility of finding objects of larger size should not be neglected but the general probabilities are heavily in favour of the smaller features.

(c) *Choice of the Canadian Shield as the area of search.* The Canadian Shield, composed of Precambrian rocks, has an area of 1,800,000 square miles or about half the area of Canada. Excellent summaries of the topography and geology of the Shield have been given by Hanson (1947) and by Cooke (1947). They point out that the major part of the Shield consists of granite and gneiss but that there are also numerous bodies of deformed and altered volcanic rocks and sediments which show evidence of the influence of mountain building forces. In the southeastern part of the Shield there are considerable areas underlain by crystalline limestone. Some areas of the Shield are covered by relatively flat-lying volcanic and sedimentary rocks of late Precambrian age. Islands or outliers of Palaeozoic age are found in numerous locations in the southern part of the Shield. The age of the most recent Precambrian rocks is considered to be in excess of 500,000,000 years. A majority of

the Shield rocks are probably much older, some of the ages quoted being as great as 1,500,000,000 to 2,000,000,000 years.

The probability that most areas of the Precambrian Shield have remained geologically undisturbed for a very long time has suggested that it would be a good place to look for old craters. The absence of sediments younger than about 500,000,000 years would appear to ensure that, granted the meteorite theory of lunar crater formation, there must have been many similar craters formed on the earth which have not been covered by later sediments. No doubt the vast majority would have been removed by erosion but some might well remain to reward the investigator.

In addition to the possibility of finding old craters it may be pointed out that at least one recent crater (the New Quebec Crater) has been found in the Shield and it is possible that others might be found also. In this particular respect the Shield may be neither better nor worse than other areas, but on balance it was considered that it should be more favourable for a search of this kind than other regions of the country.

(*d*) *Technique of investigation.* The Canadian Air Photo Library contains some 3,000,000 aerial photographs in the form of 10″ × 10″ paper prints covering practically all the land area of the country. A large proportion of this coverage is by vertical photographs taken from various heights ranging from 5,000 to 35,000 feet. Other areas have been photographed by the trimetrogon or three camera technique in which three shots are taken simultaneously, one vertical and two oblique. The vertical photographs have the great advantage of showing topographical relief when examined with the aid of a stereoscope and with suitable equipment detailed relief maps can be prepared from them. The trimetrogon photographs are by no means negligible for the purpose of searching for circular features, but they offer less opportunity for confirming the character of such a feature once it is found.

The facilities of the library were kindly placed at our disposal by Mr. E. J. Meek of the Surveys and Mapping Branch, Department of Mines and Technical Surveys, and two of our group spent approximately three and a half months studying the photographs. The prints were first examined directly by eye and then under moderate magnification. If anything of a circular or partially circular nature was found it was carefully examined with the aid of a stereoscope to see whether it bore any resemblance to a crater.

In the course of these studies a great many lakes were examined many of which had round or roundish outlines and the question naturally arose as to whether some of them might have been old craters. In the absence

of a detailed examination on the ground it would normally be difficult to prove the contrary. However, it appears that in the absence of major disturbing factors (such as for example the effect of glaciation which tends to give rise to elongated features) the most normal shape for a lake is round or nearly round and there are many different agencies which are capable of producing a lake of this shape. Accordingly, in the absence of raised rims or other indications of artificiality which would set them apart from the ordinary run of lakes, such features have been discarded. It is possible that a re-appraisal of the situation in the future might bring into the picture some features not now seriously considered but it seems best for the present to proceed cautiously.

Apart from lakes which present special problems there have been several other circular features observed, none of which is of completely unambiguous origin. The question has arisen as to whether we should publish descriptions of these features before detailed investigations on the ground have been made. It has been decided to do so for the following reasons:

(1) The number of these features and the location of some of them in remote areas of the country make it likely that many years will elapse before all of them are thoroughly investigated.

(2) If some interesting discoveries are made public it is hoped that it may stimulate similar searches elsewhere.

(3) This particular investigation is limited mainly to such information as can be gained from a study of aerial photographs and it is proposed, for the most part, to leave the detailed studies at the sites of the craters to Observatory staff members or other scientists who have geophysical or geological techniques at their disposal. The publication now of the location and general description of craters or crater-like structures will afford opportunities for investigation and discussion which should hasten the time when the origin of these interesting features is thoroughly understood. While some or all of them may prove to be unrelated to the lunar problem the study of a number of diverse features should eventually make it possible to separate those which are significant in this sense from those which are not.

(*to be concluded*)

NOTES FROM OBSERVATORIES

Dominion Astrophysical Observatory, Victoria, B.C.

Staff. Dr. Anne B. Underhill returned to the Observatory in July, having spent the academic year 1955–56 at Harvard College Observatory. Mr. J. R. White joined the staff in May as Instrument Maker. Mr. E. H. Richardson resigned in May to carry on graduate study in physics at the University of Toronto.

The following, all students from the University of British Columbia, held temporary appointments at the Observatory during the summer: E. Butkov, J. D. Francis, A. K. Goodacre, and S. C. Morris.

Dr. R. M. Petrie attended the National Science Foundation Conference on the Cosmic Distance Scale at the University of Virginia in April.

Dr. A. McKellar gave an invited paper at the Liege Conference on Molecules in Astronomical Objects in July.

Dr. Jean K. McDonald will spend the academic year 1956–57 at the University of California as Visiting Assistant Professor in the Department of Astronomy.

National Science Foundation Conference in Victoria. Some 15 astronomers from the United States and Canada came to the Observatory in August to attend the Conference on Binary Stars, sponsored by the National Science Foundation. The purpose of the Conference—to encourage the study of double stars—was achieved through discussions of astrometric, photometric and spectroscopic problems and through plans for co-ordination of study by the various powerful techniques now available. Problems of the origin and evolution of double stars were brought to the attention of observational astronomers. Sixteen invited papers were presented at the Conference, and these were supplemented by active discussions. It is expected that the proceedings of the Conference will appear in this Journal at a later date.

Visitors. Visitors to the Observatory included: G. Herzberg of the National Research Council, W. H. McCrea of the University of London, J. H. Hodgson and M. Thompson of the Ottawa Observatory, and C. H. Cleminshaw of the Griffiths Planetarium.

J. K. McD.

THE BRYDONE JACK OBSERVATORY, FREDERICTON, N.B.

Honorary Degree: At the Encaenia of the University of New Brunswick held on Thursday, May 17th, 1956, Honorary Doctor of Science degrees were conferred on Dr. C. S. Beals, the Dominion Astronomer, Dr. J. W. Sisam, Dean of Forestry at the University of Toronto, and Dr. R. B. Woodward of Harvard University.

The citation for Dr. Beals follows:

Your Honour; Mr. President:

No single Canadian can boast such widely ranging contacts as the Dominion Astronomer. He enters our homes daily as an intimate friend with the one o'clock time-signal. He informs us officially when we have had an earthquake. He informs us also when stars millions of light-years away have had an analogous experience. They are apparently all one to him, although the latter demands more abstruse calculations.

His researches in the field of stellar spectra and interstellar matter are considered by the scientific world monumental, and first among high honours have won him membership in the great Royal Society of London.

It is not often that such brilliance goes with administrative genius. Yet since his present appointment in 1947 he has made of a routine observatory one of the leading research institutions of Canada.

To the layman a more obvious monument to the permanence of his achievements would seem that he persists as Dominion Astronomer in a Dominion Observatory in a country that has itself ceased (except perhaps in certain scattered localities) to be termed a Dominion.

The presentation of Dr. Beals for the degree is, according to tradition, rendered in Latin; an English translation is also given.

"Insignissime Praeses et tota Universitas,

praesento vobis

CARLEOLUM SMITH BEALS

astrologum astrologorum, cuius — velut alterius Epicuri —

"Vivida vis animi pervicit, et extra
Processit longe flammantia moenia mundi, . .
Unde refert nobis victor quid possit oriri
Quid nequeat"; (Lucretius I, 72–75)

ut admittatur honoris causa ad gradum

DOCTORIS IN SCIENTIA"

"Illustrious Mr. President and this whole University body

I present to you

CARLYLE SMITH BEALS

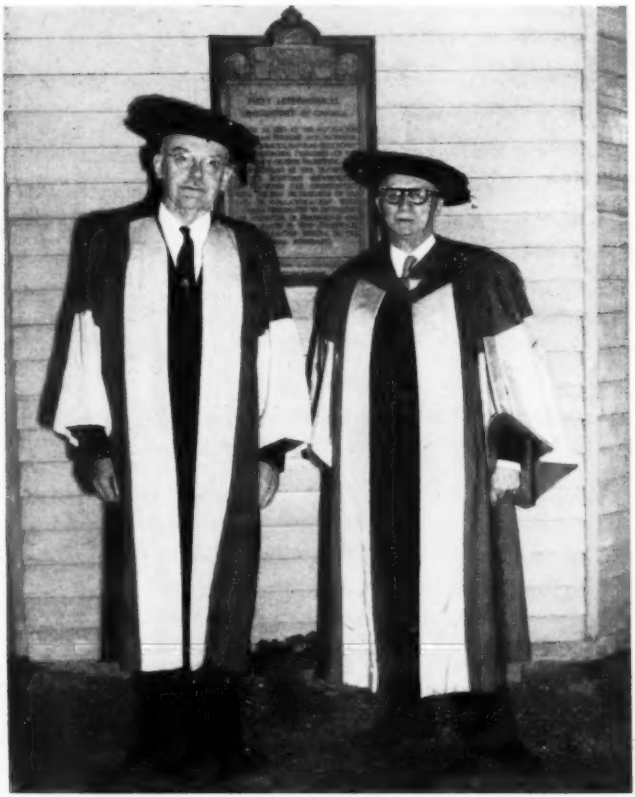
pre-eminent astronomer, of whom—as of a second Epicurus—

"His will and hardy wisdom won its way;
And forward thus he fared afar, beyond
The flaming ramparts of the world . . .
Whence he to us, a conqueror, reports
What things can rise to being, what cannot"; (Leonard)

that he be admitted to the honorary degree of

DOCTOR OF SCIENCE"

J. E. K.



A memorable occasion is recorded at The Brydone Jack Observatory, Fredericton. Dr. C. S. Beals (on left) immediately prior to receiving an Honorary Degree of Doctor of Science from the University of New Brunswick is photographed with Dr. C. McN. Steeves, University Senate member responsible for the preservation and marking of this historic Observatory.

REVIEW OF PUBLICATIONS

Vistas in Astronomy, volume 1, edited by A. Beer. Pages xvi plus 776, 7½ × 10 in. London, Pergamon Press, 1955. Price $28.00.

This book is the first of two volumes dedicated to F. J. M. Stratton, Emeritus Professor of Astrophysics in the University of Cambridge. The purpose of the two volumes is to cover all fields of astronomy, not from the point of view of a single author, but rather from as many points of view as possible. Altogether there are 215 authors representing 26 nations. Of these, 36 are physicists, geophysicists, mathematicians and historians. All of the papers originally submitted in languages other than English have been translated into English for publication.

The present large volume covers the topics of Co-operation and Organization, History and Philosophy, Dynamics, Theoretical Astrophysics, Instruments, Radio Astronomy, and Solar Physics. Each of these topics includes up to thirty individual articles by noted astronomers in the field. The articles are not intended to be of the kind that would be published in a journal or handbook of astronomy. Rather the editor emphasized to the contributors that "the purpose of the book was to present original articles and reviews, reflecting fully and critically the present situation and recent advances in astronomy and related fields". The articles were to be written in such a way that they would be valuable not only to the expert but also to the more general reader. Each article was to begin with a statement of the problem and a brief summary of previous work, and conclude with a survey of the unsolved problems and future research possibilities. The editor was also careful to ensure that duplication of material would not occur except in a few circumstances where such duplication seemed advantageous.

The result is a most fascinating book both for the specialist and non-specialist. The editor has very successfully preserved the aims mentioned above with the result that graduate students, in particular, will find this book very valuable both as an introduction to research and also as an introduction to the research work of a great many of the world's leading astronomers in all countries.

It is of course impossible to review, or even list, all of the articles in a book of this scope. One can mention only a few of particular interest. In

the section on History and Philosophy there is an interesting article by Needham on early Chinese astronomy and another by Hartner on the history of Renaissance astrology and astronomy. The section on instruments is of particular interest because of the rapid development of new techniques in the last few years. Linfoot has an article on the various types of Schmidt cameras and telescopes and the aberrations in such instruments. The design of efficient astronomical spectrographs for large telescopes, which is one of the most important instrumental problems at the present time, is discussed by Bowen of the Mount Wilson and Palomar Observatories. There are several articles on photoelectric devices for telescopes including new applications to electron telescopes. The Radio Astronomy section has articles dealing with many phases of the subject. Outbursts of radio noise from the sun are discussed by Wild. The application of interstellar hydrogen 21-cm. measurements to the structure of the galaxy is outlined by Oort who is recognized as an authority on galactic structure.

The above-mentioned articles give only a small sample of the many fine articles in the book. As in any book of this kind, there are bound to be some articles of limited interest. Fortunately these are very few. The large number of very fine articles makes this a book which every astronomer and student should have available.

J. B. O.

L'Univers by Paul Couderc. Pages 132, 4½ × 7 in. Paris, Presses Universitaires de France, 1955.

This booklet by a well-known author and astronomer of the Observatory of Paris has appeared as No. 687 in the series "Que sais-je?" (What do I know?). It contains six chapters as well as a preface and two appendices.

The chapters are as follows: I. General survey and definitions. II. Our galaxy. III. Stellar populations. Evolution and age of stars. IV. Galaxies. V. The red shift in the spectra of galaxies. VI. Cosmology. Appendix I is on the atomic reactions of proton and carbon cycles, appendix II contains formulae for finding the age of radio-active minerals.

The booklet is a handy review of modern astronomy and its problems and can be read easily by anyone who has a moderate knowledge of French.

G. A. B.

METEOR NEWS

By Peter M. Millman, *National Research Council, Ottawa*

Visual Meteor Observing During the I.G.Y.

One of the greatest international programmes of scientific research ever attempted will commence on July 1, 1957. This is the International Geophysical Year, commonly referred to as the I.G.Y. Already over 40 different nations have indicated their intention of co-operating, and at many points the construction of equipment and the preparation of field stations has been going on for over a year. The official period of observation for the I.G.Y. will be from July 1, 1957 to December 31, 1958. Many of the programmes will have an advance trial in June 1957, and will extend through January 1959.

The emphasis in I.G.Y. is on special observational projects which will benefit from having observations carried out over a wide area and, in particular, over a network extending across all longitudes around the Arctic and Antarctic regions. Among the numerous disciplines included in the planning for I.G.Y. we find observations of the ionosphere, of terrestrial magnetism, of the aurora and air glow, and of meteors. Certain days have been assigned in advance as Regular World Days (R.W.D.). In addition to these, Special World Intervals (S.W.I.) will be chosen at shorter notice. The R.W.D. and S.W.I. will be periods of concentrated activity on all the I.G.Y. programmes. The R.W.D., as listed by the International Scientific Radio Union (U.R.S.I.) in their Information Bulletin. no. 90, March–April 1955, are given in Table I.

At the National Research Council in Ottawa, radio equipment working at a wave-length of 9.2 metres will be operated throughout the I.G.Y. on a 24-hour basis for the purpose of recording the back-scatter radar echoes from meteors. This will give a continuous record of meteor rates, day and night. It is of considerable importance to be able to calibrate these radio rates against visual meteor counts and an I.G.Y. visual meteor programme is being organized jointly by the National Research Council and the Dominion Observatory. Special observing forms and instructions for this project will be printed and it is hoped that these will be ready by the end of 1956. This will give all observers who wish to co-operate a chance to become familiar with the programme prior to the commencement of I.G.Y.

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One of the greatest international programmes of scientific research ever attempted will commence on July 1, 1957. This is the International Geophysical Year, commonly referred to as the I.G.Y. Already over 40 different nations have indicated their intention of co-operating, and at many points the construction of equipment and the preparation of field stations has been going on for over a year. The official period of observation for the I.G.Y. will be from July 1, 1957 to December 31, 1958. Many of the programmes will have an advance trial in June 1957, and will extend through January 1959.

The emphasis in I.G.Y. is on special observational projects which will benefit from having observations carried out over a wide area and, in particular, over a network extending across all longitudes around the Arctic and Antarctic regions. Among the numerous disciplines included in the planning for I.G.Y. we find observations of the ionosphere, of terrestrial magnetism, of the aurora and air glow, and of meteors. Certain days have been assigned in advance as Regular World Days (R.W.D.). In addition to these, Special World Intervals (S.W.I.) will be chosen at shorter notice. The R.W.D. and S.W.I. will be periods of concentrated activity on all the I.G.Y. programmes. The R.W.D., as listed by the International Scientific Radio Union (U.R.S.I.) in their Information Bulletin, no. 90, March–April 1955, are given in Table I.

At the National Research Council in Ottawa, radio equipment working at a wave-length of 9.2 metres will be operated throughout the I.G.Y. on a 24-hour basis for the purpose of recording the back-scatter radar echoes from meteors. This will give a continuous record of meteor rates, day and night. It is of considerable importance to be able to calibrate these radio rates against visual meteor counts and an I.G.Y. visual meteor programme is being organized jointly by the National Research Council and the Dominion Observatory. Special observing forms and instructions for this project will be printed and it is hoped that these will be ready by the end of 1956. This will give all observers who wish to co-operate a chance to become familiar with the programme prior to the commencement of I.G.Y.

The I.G.Y. visual meteor programme will stress the following points:

(1) Group counts of meteors over periods of one hour or longer;
(2) Individual magnitude estimates of every meteor to the nearest half magnitude;
(3) Shower identification of the meteors wherever possible;
(4) Observations on the R.W.D. listed in Table I and where possible on additional moonless nights.

The visual plotting of meteors will not be required as this has become less important since the advent of fast cameras like the Super-Schmidts.

It is hoped to enlist the aid of a large number of meteor observers, particularly those in the latitude range 35°N. to 55°N. All visual counts made will be of interest since the radio recording will operate continuously.

Those who are interested in co-operating in this special I.G.Y. meteor project can write me at the National Research Council, Ottawa, and instructions and observing forms will be sent as soon as these have been prepared.

TABLE I

REGULAR WORLD DAYS FOR I.G.Y.

(Calendar Dates in Universal Time)

1957 June **27** (Thu.)	1958 Jan. 3 (Fri.) M	1958 Aug. 7 (Thu.)
28 (Fri.)	4 (Sat.) M	12 (Tue.) M
29 (Sat.)	**19** (Sun.)	14 (Thu.) M
	20 (Mon.)	**15** (Fri.)
July 4 (Thu.)		
26 (Fri.)	Feb. 10 (Mon.)	Sept. 6 (Sat.)
27 (Sat.) M	**18** (Tue.)	**13** (Sat.)
	19 (Wed.)	14 (Sun.)
Aug. 12 (Mon.) M	26 (Wed.)	20 (Sat.)
25 (Sun.)		
26 (Mon.)	Mar. **20** (Thu.)	Oct. 10 (Fri.) M
	21 (Fri.)	11 (Sat.)
Sept. 1 (Sun.)	28 (Fri.)	**12** (Sun.)
23 (Mon.)		13 (Mon.)
24 (Tue.)	Apr. 18 (Fri.)	
30 (Mon.)	**19** (Sat.)	Nov. 4 (Tue.)
	20 (Sun.) M	10 (Mon.)
Oct. 22 (Tue.) M		**11** (Tue.)
23 (Wed.)	May 5 (Mon.) M	18 (Tue.)
24 (Thu.)	**18** (Sun.)	
	19 (Mon.)	Dec. **10** (Wed.)
Nov. 14 (Thu.)		11 (Thu.) M
21 (Thu.)	June 9 (Mon.)	13 (Sat.) M
22 (Fri.)	**17** (Tue.)	17 (Wed.)
	18 (Wed.)	
Dec. 13 (Fri.) M	24 (Tue.)	1959 Jan. 3 (Sat.) M
16 (Mon.)		4 (Sun.) M
21 (Sat.)	July **16** (Wed.)	9 (Fri.)
22 (Sun.)	17 (Thu.)	**10** (Sat.)
	27 (Sun.) M	

Dates of New Moon indicated by bold face type.
M—periods of special meteor shower activity.

VARIABLE STAR NOTES
American Association of Variable Star Observers

By MARGARET W. MAYALL, *Recorder*

Miscellaneous notes on the activities of some A.A.V.S.O. variables during 1955 and early 1956.

001838 *R And.* During the current epoch, the observations of R And have followed the predicted curve. The maximum in the middle of September was about half a magnitude fainter than normal.

003179 *Y Cep.* A circumpolar variable in need of more observations. A 9th magnitude maximum in January 1956 followed a 10th magnitude one in February 1955.

005840 *RX And.* This rapidly varying Z Camelopardalis-type variable has a range of 2½ magnitudes and has been very active throughout the year.

010630 *U Scl.* A 9th magnitude maximum was observed early in December.

010884 *RU Cep.* This bright circumpolar variable has been nearly constant at about 8.8 for the last year. It is a good object for observers with small instruments.

011041 *UZ And.* Bright and faint maxima continue to alternate. A 9½ magnitude one the last of November followed the 10½ magnitude maximum previously noted in January 1955.

013238 *RU And.* The range of this variable is now back to a normal 3 magnitudes (10½ to 13½). For more than 10 years after 1940, it varied only 1 magnitude. It has gradually increased during the last few years.

013418 *UV Cet.* No flare observed.

015254 *U Per.* The maximum in December was double humped, with peaks 90 days apart.

020356 *UV Per.* No maximum has been observed of this U Geminorum-type star since December 1952.

021403 *o Cet.* The maximum (3.7 mag.) on January 9, 1956 occurred near the predicted date.

022150 *RR Per.* A bright maximum (8.6) occurred early in April 1955.

022426 *R For.* Another bright maximum (8½), the second in succession, was observed in August. They follow two 9½ magnitude ones in 1952 and 1953.

041619 *T Tau.* This RW Aurigae-type variable continues to have a small range of less than one magnitude variation.

042215 *W Tau.* Continues to have variations of less than one magnitude.

043065 *T Cam.* A very narrow minimum was observed early in January 1956. It was less than 100 days wide at the 12th magnitude, at least 50 days less than at the previous minimum.

043274 *X Cam.* A brighter-than-8 maximum early in April 1955, followed by fainter ones in August and January 1956.

043263 *R Ret.* A very faint maximum, about two magnitudes fainter than normal, was observed in April 1956.

052372 *RR Cam.* This interesting semi-regular circumpolar variable is a good object for small telescopes with its variation from about 9½ to 11.

053337 *RU Aur.* A normal maximum (9½) early in April 1956 follows the very faint one (11½) in the latter part of December 1954.

054319 *SU Tau.* This R CrB-type variable had a long minimum, 14th magnitude or fainter, throughout the 1955–56 observing season. A single observation by Cragg on May 18, 1956 indicated a possible return to maximum brightness.

054615a *Z Tau.* Mean maximum magnitude of Z Tauri is 10.4, but it was not observed above 12th magnitude at the maximum near the middle of September. The preceding maximum in May 1954 was about 10th magnitude.

060547 *SS Aur.* The following maxima of this U Gem-type variable were observed during 1955: 2435158, 10.6; 5237, 10.7; 5354 (?); 5445, 10.9; 5500, 10.5; 5553, 10.6.

061115 *CZ Ori.* Ten maxima were observed during 1955 of this U Gem-type star.

062105 *SW Mon.* After several years of comparative inactivity, SW Mon was observed to have nearly 2 magnitudes variation during the observing season of 1955–56.

074922 *U Gem.* Two maxima were observed during 1955, one the last of January, the other the latter part of December.

082953 *SW UMa.* Last observed maximum of this U Gem-type variable was on J.D. 2431080, in December 1953.

095458 *RR Car.* This semi-regular variable has been nearly constant at magnitude 8½ since January 1955.

103270 *RZ Car.* A bright maximum (9½) the first of May 1955, followed by a fainter one (10½) the last of January 1956.

123160 *T UMa.* Bright and faint maxima continue to alternate.

145254 *Y Lup.* Two maxima, each about one magnitude fainter than normal, were observed in the middle of January 1955 and in the middle of February 1956.

145971 *S Aps.* This R CrB-type variable has had erratic and rapid changes of about one magnitude during the year.

151822 *RS Lib.* The last three maxima have been of increasing brightness: mid-February 1955, about 8.6 magnitude; last of August, 7.9; and early April 1956, about 7.2 magnitude.

154428 *R CrB.* A shallow minimum began early in November 1955, and lasted until May 1956. During the minimum, the star was observed to vary erratically between 6.5 and 7.0, with one drop to about 7.5 in early April.

161138 *W CrB.* A bright 8th magnitude maximum was observed the first of August, followed by a 9th magnitude one in early April 1956.

162119 *U Her.* A bright maximum (6.8 magnitude) in mid-April 1955, follows the faint one (8.6) in the latter part of March 1954.

164319 *RR Oph.* A bright 8½ magnitude maximum was observed in November 1954. The maximum in the latter part of July 1955 was about one magnitude fainter.

164403 *TT Oph.* An RV Tau-type star which varies from about 9½ to 11 in a double period of 61 days, with alternating deep and shallow minima.

165905 *TX Oph.* Another RV Tau-type variable with a double period of about 140 days. Its range is usually between 9½ and 11, but at times it drops as faint as 12th magnitude. More observations are needed.

172486 *S Oct.* A bright 7½ magnitude maximum was observed the last of June 1955, followed by a faint 9th magnitude maximum in the middle of March 1956.

174162 *W Pav.* The bright 8th magnitude maximum in October 1954 was followed by one of 10th magnitude the last of July 1955.

180222a *VX Sgr.* The 1955–56 minimum of this semi-regular variable (837^d ?)

was between 9 and 10 magnitudes, about 2 magnitudes brighter than normal. It may be the beginning of another long period of inactivity, such as seems to occur after several epochs of fairly regular variation between 7th and 12th magnitudes.

184205 *R Sct.* In the beginning of 1955, R Scuti had three 7th magnitude minima 50 to 60 days apart. After a series of shallower minima, an 8th magnitude one was observed early in February 1956.

190925 *S Lyr.* Maxima of 10th magnitude (2 mags. brighter than the mean) were observed the middle of September 1954 and early in December 1955.

191033 *RY Sgr.* This R CrB-type variable was constant at about 6½ magnitude until early December 1955. No observations were received until the last of January 1956 when de Kock found it down to 9th magnitude. By the first of March, it reached 11, then started to brighten, until it was back to 8th magnitude by mid-May.

194632 *chi Cyg.* The slope of the increasing branch of the light curve continued very steep at the 1955 and 1956 maxima.

195032 *EY Cyg.* No maximum observed of this U Gem-type star.

195109 *UU Aql.* Three maxima were observed of this U Gem star: July 10, Sept. 9, and Nov. 15.

195377 *AB Dra.* This Z Cam-type star varies rapidly from about 12½ to fainter than 15, with a period of about 12 days.

195656 *RR Tel.* This peculiar nova-like variable remained fairly constant between magnitudes 8.9 and 9.2.

200357 *S Cyg.* A faint maximum (magnitude 11.3) was observed in mid-October.

205782 *T Oct.* Two faint 9th magnitude maxima in August 1955 and March 1956 follow an 8th magnitude one in January 1955.

210868 *T Cep.* During the rise to maximum in 1955, T Cephei had a marked hump or secondary maximum, about 100 days before the true maximum, and about 0.8 magnitude fainter. Observed maximum was near the middle of August, magnitude 6.2.

220912 *RU Peg.* Maxima of this U Gem-type variable were observed on Sept. 9, Nov. 12, and Dec. 8, 1955, the last two only 26 days apart, instead of the mean 70 days.

221255 *CP Lac.* This 1936 nova is now below 15th magnitude.

230759 *V Cas.* A faint 9th magnitude maximum was observed near the middle of January 1955, followed by a slightly brighter one (8½) in the middle of September.

235265 *R Tuc.* A very faint maximum (magnitude 11.3) was observed near the middle of December 1955. The previous one, early in March, was slightly fainter than the mean of 9.9.

235350 *R Cas.* A bright, 6th magnitude maximum was observed in the latter part of December 1955. The previous maximum in November 1954 was a little below 7th magnitude.

A.A.V.S.O. Annual Meeting. The 45th Annual Fall Meeting of the A.A.V.S.O. will be held the week-end of October 19–20, 1956, at the Springfield Museum of Natural History, Springfield, Massachusetts. Official notices will be mailed to members before the meeting, but any interested persons are invited to attend, and should write to A.A.V.S.O. Headquarters for more information.

erratum. Variable Star Notes, this Journal, vol. 50, no. 3, p. 135 4th paragraph; for "The predicted maximum for 1956 . . ." read "The predicted minimum for 1956 . . ."

Nova Search Report (from George Diedrich, Division Chairman)

Vacation schedules have made it necessary to write this report too early to catch some of the June observations. No one discovered a Nova during the last two months but the following observers watched their areas for the number of area-nights indicated after their name, first the May and then the June 1956 total.

JIM BRECKINRIDGE 14, 0; DELORNE DIEDRICH 2, 5; GEORGE DIEDRICH 13, 9; RICHARD GEMBERLING 9, 20; BEAUFORT RAGLAND 4, 7; DONALD ROSENFIELD 0, 8.

Observations received during May and June 1956: In May 3,052 observations were received from 54 observers, and in June 2,678 from 45, a total of 5,730 for the two months.

Observer	May		June		Observer	May		June	
	No. Var.	No. Ests.	No. Var.	No. Ests.		No. Var.	No. Ests.	No. Var.	No. Ests.
Adams, R. M.	56	164	55	161	Kelly, F. J.	10	10	10	10
Anderson, C. E.	26	41	43	65	Kimball, M.	43	54	...	...
Arnold, J.	...	...	7	13	de Kock, R. P.	123	506	128	526
Aronowitz, C.	2	2	...	...	Kofeod, R.	5	5	...	...
Ball, A. R.	1	1	13	16	Lacchini, G. B.	5	9	34	104
Barber, W. F.	...	...	1	2	Maran, S. P.	22	22	5	5
Beidler, H. B.	...	...	6	7	McPherson, C. A.	19	19	...	...
Berg, R.	53	101	51	56	Melville, E. C.	12	15	11	13
Bicknell, R. H.	...	...	15	86	Miller, R. W.	8	13	...	...
Bieda, S. W.	2	3	...	...	Montague, A. C.	18	31	24	42
Breckinridge, J.	7	14	11	26	Morgan, F. P.	16	34	8	16
Byrd, W.	1	6	...	...	Oravec, E. G.	194	296	145	277
Carlisle, J. H.	2	5	2	5	**Overbeek, M. D.	24	34	...	...
Carpenter, C. B.	...	...	33	33	Parker, P. O.	52	52	43	43
Charles, D. F.	10	16	...	...	Pearcy, R. E.	...	...	1	1
Cragg, T. A.	143	145	160	164	Peltier, L. C.	20	55	17	73
Cunningham, R.	1	1	...	...	Pilcher, F.	3	5	9	15
*Darsenius, G. O.	12	20	11	20	Pivonka, R. J.	4	4	...	...
Deemer, R.	2	2	7	8	Renner, C. J.	98	109	...	...
Diedrich, DeL.	1	1	...	...	Rizzo, P. V.	16	18	13	15
Diedrich, G.	3	7	7	15	Rosebrugh, D. W.	10	49	12	62
Erpenstein, O. M.	10	23	1	1	Royer, R.	7	7	12	18
Estremadoyro, V. A.	5	5	...	...	Schultz, G. W.	11	11	...	...
Fernald, C. F.	136	256	158	337	Segers, C. L.	...	...	24	63
Fink, R.	1	1	...	...	Skaritka, P.	45	54	...	...
Ford, C B.	122	127	139	141	Solomon, L.	53	62	12	22
Gleason, W. S.	...	...	4	5	Taboada, D.	38	39	...	...
Glenn, W. H.	21	23	6	6	Thurn, V. W.	...	...	3	6
Goldenblatt, P. P.	45	84	34	35	Tsai, C. H.	20	31	...	...
Goodsell, J. G.	4	4	3	3	***Venter, S. C.	75	249	...	...
Hartmann, F.	122	134	112	125	Wend, R.	...	...	2	2
Hein, G.	41	53	14	17	Witalis, R.	...	...	1	1
Howarth, M.	...	...	17	17	Wyckoff, J.	18	20	...	...

* plus $1^h\ 35^m$ BD +55° 1823; 20^m DO Cep
** plus $1^h\ 40^m$ UV Cet
*** plus $2^h\ 20^m$ UV Cet

A.A.V.S.O. Headquarters,
4 Brattle Street,
Cambridge 38, Massachusetts,
July 1956.

NOTES AND QUERIES

Relativistic Advances of Perihelions

Newton's law of gravitation predicts that the path of each planet will deviate slightly from an ellipse because of the attractions of the other planets. This deviation is usually described as the advance of the perihelion, the point of the orbit nearest the sun. While the planet moves in an ellipse the longest diameter of the ellipse slowly rotates in the direction the planet is moving. However, Einstein's general theory of relativity, because of the so-called curvature of space in the vicinity of matter, predicts an advance of the perihelion which is slightly in excess of the non-relativistic motion of the planet.

At the March 1956 meeting of the American Astronomical Society, R. L. Duncombe, of the U.S. Naval Observatory, announced results for the planet Venus derived from his recent analysis of many thousands of observations made from 1750 to 1949. For the first time the observational results have been accurate enough to detect the relativistic effect for Venus. Duncombe quoted the following values and probable errors for the advance of the perihelions of Mercury, Venus and Earth which are in excess of those predicted by all known Newtonian forces. G. M. Clemence derived the figures for Mercury, and Clemence, H. R. Morgan and Duncombe derived those for Earth. The observed discrepancies are followed by the predicted relativistic motions calculated by Clemence. All values are in seconds of arc per century.

	Mercury	Venus	Earth
Observed Discrepancy	$43''.11 \pm 0''.45$	$8''.4 \pm 4''.8$	$5''.0 \pm 1''.2$
Relativistic Prediction	$43''.03$	$8''.6$	$3''.8$

For each planet the two values agree within the probable errors. This close agreement between observed and predicted values gives considerable support to the general theory of relativity.

Donald C. Morton

New Director for the Commonwealth Observatory, Australia

Dr. Bart J. Bok, of Harvard Observatory, has been named director of the Commonwealth Observatory, near Canberra, Australia. He succeeds Prof. R. v. d. R. Woolley who is now Astronomer Royal and in charge of the Greenwich Observatory at Herstmonceux.

The Commonwealth Observatory has expanded since the war until it is the best equipped observatory in the southern hemisphere. The main telescope is a 74-inch reflector, the proto-type of which is that of the David Dunlap Observatory. Besides this are reflectors of 50, 30 and 20 inches, and other specialized equipment. Other institutions have been invited to erect instruments on Mount Stromlo: a 26-inch Yale-Columbia refractor is already in operation, and a 20-inch Schmidt telescope of the Uppsala Observatory, Sweden, is expected to be mounted this year. Expansion is continuing.

Dr. Bok, who will become the new director on February 1, 1957, is well known for his work on the southern Milky Way and galactic structure. He has also been active in the field of radio astronomy, and in his new post will continue this interest by working in collaboration with the radiophysics laboratory at Sydney. He will also be professor of astronomy at the Australian national university in Canberra.

R. J. N.

A New Globular Cluster near the Galactic Centre

Although there are quite a few globular clusters known in the region toward the galactic centre, in the constellation Sagittarius, none had been observed in the galactic plane because of heavy absorption by interstellar clouds. However, these clouds become more transparent at longer wave-lengths, in the red and infra-red region of the spectrum. A photograph taken in this spectral region can reveal more details in that part of the sky.

The discovery of a new globular cluster was announced by Jean Dufay, Pierre Berthier and Bernard Morignat of the Observatory of Haute-Provence in France on an infra-red sensitive plate ($\lambda \sim 8900$ A.) with the 32-inch reflector and reported in the *Publication de l'Observatoire de Haute-Provence*, vol. 3, no. 17.

The co-ordinates of the new cluster are (equinox 1950):

α $-17^h27^m54^s$	l $325°.1$
δ $-29°56'.9$	b $+ 0°.7$

The diameter of the cluster is about 1'.3 with an apparent condensation toward the centre. The estimated distance is of the order of one thousand parsecs, just about the same as that of the internal spiral arm of our galaxy discovered recently by W. W. Morgan and others.

G. A. B.

Honours for Dr. Gerhard Herzberg

Dr. Gerhard Herzberg, who is Director of the Division of Pure Physics at the National Research Council, was elected president of the Canadian Association of Physicists at their annual meeting in June. A month later he received the distinction of being awarded the honorary degree of Doctor of Science by the National University of Ireland in Belfast. He was invited to give the introductory report to the Symposium on Molecules in Astronomical Objects held this summer at Liege, Belgium.

R. J. N.

In the Society's Library

In order to make the library of The Royal Astronomical Society of Canada more useful, it is planned to give members an opportunity to become more acquainted with the contents of the library by publishing in The Journal lists of new books and periodicals which the library has received. Books and periodicals may be borrowed from the library by mail for a period of one month by sending a request to the librarian at 252 College Street.

In this issue a few of the library's periodicals are mentioned. Undoubtedly the most popular periodical is *Sky and Telescope* which contains sky charts, telescope-making information, popular and semi-popular articles, and many fine photographs. *The Irish Astronomical Journal* is very similar to our own Journal in content. Another periodical which will be of interest particularly to French-speaking members is *L'Astronomie*. This small attractive magazine is written in French and contains popular articles and various astronomical data.

J. B. Oke, *Librarian.*

MEETINGS OF THE SOCIETY

AT EDMONTON

December 10, 1954—Annual dinner meeting. After dinner in the Corona Hotel banquet room, the meeting was called to order by the president, at 8:00 p.m.

The HANDBOOK talk was given by Mr. Campbell. Reports were given by the Observers' Group, the Librarian, Treasurer, Secretary and the Nominating Committee. The Slate was declared elected.

Mr. Frank Page, the President-elect, then showed fine coloured slides, taken during a summer tour of the British Isles and part of Europe. Both his slides and his commentary were much enjoyed and appreciated. There were 36 members and visitors present.

January 19, 1955—The meeting was called to order by the President at 8:20 p.m.

Correspondence: A letter was read from Toronto regarding putting the names of the members on the mailing list and avoiding the sending of Journals to those who are not likely to pay their fees. There was also an appeal for special donations from those who felt they could contribute in this way.

It was moved and seconded that flowers and a card be sent to Dr. Campbell in the University Hospital.

The HANDBOOK talk was given by Dr. Crosby.

A report was given by the Observers' Group on some details of the fireball observed in Western Canada on December 19, 1954. A detailed report of this will appear elsewhere.

The main paper was given by Mr. N. L. Cowin of Canadian Union College, Lacombe, his subject being "Time-keeping". He attempted to answer the question "What Times has Man Observed and How?" The day is now 24 hours but has had other divisions, including the division from sunrise to sunset into 12 hours which vary in length with the seasons. The year is not evenly divisible by any other of the natural astronomical periods. The month used to be started by the crescent moon and gave uneven periods. This was "fixed up" by intercalary months. About seven in 19 years were used to keep the seasons nearly uniform in the year. Some of the confusion in the calendar was dispelled by using astronomical cycles called the Saros and the Metonic cycle. Then Julius Caesar fixed the year on the basis of the sun alone. This calendar was later reformed by Pope Gregory by omitting leap years in even centuries not divisible by 400. The week is alleged to have started by the account of the Creation. There is no astronomical movement to suggest the weekly cycle. For daily time-keeping clocks must be checked by the rotation of the earth and the position of the sun at noon, but motion in the orbit varies this. Consequently a mean, or average sun is used and special observations are taken on certain stars to keep check on our clocks. Then time signals are sent out by national observatories, for example, on station WWV from the U.S. Naval Observatory, and a similar service is now available from Ottawa.

There were 30 members and visitors present.

February 10, 1955—The meeting was brought to order at 8:20 by the President.

In commemoration of Dr. Campbell's association with the Edmonton Centre, it was moved by Mr. Keeping, seconded by Dr. Gowan, that a letter of sympathy be sent to Mrs. Campbell and the family. Carried by a standing vote.

A short talk was given by Mr. McCurdy of the Physics Department on utilizing the moon to occult stars and to increase the resolving power of telescopes.

The purpose is to locate places on the earth's surface more accurately than 600 feet. Some applications are:

1. It may be possible to measure diameters of stars.
2. It may be possible to resolve some double stars, at present unresolved because they are between the visual and spectroscopic techniques.
3. It may be possible to investigate atmospheres of stars.

The resolving power is 1/5000 sec. of arc equivalent to that of an 800-inch telescope.

A report of the activities of the Observatory committee was given by Dr. Grayson-Smith. The small hut is to be fixed up with light and heat and Saturday public nights are to be continued on a regular basis.

The main programme was a quiz organized by Earl Milton, who divided the audience in two sections and bombarded them with questions based on the HANDBOOK.

There were 20 members and visitors present.

March 10, 1955—The meeting was called to order at 8:20 p.m. by the Vice-President, Dr. Crosby.

Dr. Crosby gave the HANDBOOK talk.

The Observers' report was given by Earl Milton, who said the Saturday public meetings were being well attended. He described briefly a new form to be used in reporting aurora observations.

The main paper of the evening was by E. H. Gowan on the subject of the Zodiac. The twelve constellations were illustrated by slides showing the star positions, and also a drawing of the figure associated with the name. The precession of the equinoxes was illustrated by a gyroscope to help explain why the *signs* and the constellations of the Zodiac do not now agree. For each of the constellations a short account of some of the mythology connected with it was given.

There were 40 members and visitors present.

April 14, 1955—The meeting was called to order by the President at 8:20 p.m.

The HANDBOOK talk was given by Dr. Crosby.

University Observatory Committee: Dr. Grayson-Smith reported that the annex soon will be fitted up to be usable.

A short talk on astronomical co-ordinates and ways of describing accurately the position of an object in the sky was given by Mr. L. E. Gads. This was well illustrated by lines on a transparent flask, and also on an umbrella.

Three films were then shown, illustrating astronomy, or sciences which have some connection with observations or ideas associated with astronomy. The titles were: Atomic Energy, The Earth and its Seasons, The Weather.

There were 38 members and visitors present.

May 12, 1955—The meeting was called to order by the President at 8:18, in Room 111 of the Arts Building.

A second letter was read concerning the Seba Beach Meteorite, which may be in the Lake. Some further investigations will be made during the summer.

The Observers' Group reported through Franklin Loehde, on a successful season. They asked more help, and suggested a programme of planetary drawings. It was expected that a new 8-inch telescope would be available at the Observatory, the gift of Mr. McCoy, Eastglen High School. Fireballs are being observed in co-operation with Regina observers.

The HANDBOOK talk was given by the Secretary.

The main paper was given by Mr. E. R. Reinelt, of the Meteorological office on the subject "Seeing Through the Air". First there is astronomical refraction, the bending of light rays as they come through the atmosphere on a slant path. This has its effects on sunrise and sunset times, on star positions, and on the use of radio navigation aids such as shoran. There is also an effect on radar and television signals giving freak reception far beyond the ordinary reliable range.

Secondly there is scintillation of stars. The changing properties of the atmosphere can cause rapid changes in the position and colour of a star, and may even show changes in shape of a planet, or a distant building.

Thirdly, horizontal visibility is of great importance to airmen, though perhaps not so significant for astronomical observations. This depends mainly on scattering which is of two kinds. Rayleigh scattering depends on the wave-length, and is responsible for the blue of the sky and for sunset colours. White scattering is so-called because it is independent of wave-length, and is due to haze or mist particles of size greater than one half micron (the micron being a thousandth millimetre). There is a border region where these types shade into each other.

Some fine pictures were shown on the screen to illustrate various features of the paper.

There were 21 members and visitors present.

October 13, 1955—The meeting was called to order by the President at 8:17 p.m.

University Observatory Committee Report was given by Dr. Grayson-Smith, the Chairman. The annex has had a lot of work done on it, and thanks are due to the Observers' Group for help with this. Annex is now being used for an introductory course on Astronomy for members and their friends.

Observing group report was mainly an account of the search for the possible meteorite in Lake Wabamun.

The HANDBOOK talk was given by Dr. Crosby.

The main item on the programme was a debate "Resolved that successful human travel in inter-planetary space is possible". The leader of the affirmative was Dr. H. Grayson-Smith who outlined the technique necessary for survival on a flight around the moon and back. Eleven pounds of oxygen per day in liquid form would be required. CO_2 would be absorbed and shot out the exhaust. Artificial gravity would be needed and could be supplied by the spin of the rocket. Radiation hazard from cosmic rays was about the normal safety standard in an X-ray Laboratory. Dr. Keeping spoke first for the negative, pointing out that there are hard facts of remoteness and large distances not easy to get around. Seven miles per second is required as an escape velocity and rockets fire mass backwards to attain this. The mass thrown away would be about 45,000 times that which went on. There are very serious accuracy problems in ever meeting an intermediate space satellite. The second speaker for the affirmative was Mr. Arthur Dalton who dealt with the problems of getting away, using a satellite at 500 miles as aid. Easterly firing adds 0.256 mi./sec. Hydro-

gen and Fluorine are proposed to give 3 times the velocity of present fuels. Special algae were suggested to make O_2 from CO_2, and a mat 4 × 4 ft. 1 inch thick in 6 inches of water would do. Space taxis would avoid the change of path on contact with the artificial satellite. The second negative speaker was Mr. Franklin Loehde who noted the extremes of temperature on the moon, and the effect of large gravity during acceleration on the human body. Protection from the sun by a space suit leads to a serious problem of getting rid of body heat.

After a short rebuttal by the leader of the affirmative there was some lively audience participation, and questions.

There were 52 members and visitors present.

November 10, 1955—The meeting was called to order by the President at 8:20 p.m.

The Nominating Committee was appointed by the President to bring in a slate of officers for the coming year.

The HANDBOOK talk was given by Mr. Gads.

Franklin Loehde reported for the Observers' Group.

The main paper of the evening was given by Dr. D. R. Crosby, on the subject "The Structure of the Universe". Within the range of the 200-inch telescope there appear to be 6 million billion stars and approximately an equal mass of gas and dust. The stars are grouped into 600 million galaxies, each containing 1 billion stars approximately. The gas and dust lies partly in clouds outside the galaxies, the density of the clouds being approximately 1 gm./10^{20} c.c. or about 1/3 gm./100 thousand cubic miles, and some clouds being as much as 500 l.y. across and containing as much mass as 100 sun-sized stars. The remainder of the gas and dust permeates the space inside the galaxies forming the so-called "interstellar gas" and "interstellar dust", the density being about 1/100 of that in the clouds; but apart from the clouds there is apparently no gas or dust in the vast spaces separating the galaxies as indicated by the free passage of "light" of all wave-lengths.

The structure of the Universe was described with the help of two distance scales. The first was a scale of 1 billion miles to the inch. The second scale was 1 million l.y. to the mile.

The paper concluded with a brief description, illustrated by slides, of the three different types of galaxies namely:

1. *Spiral Galaxies*, accounting for 80% of all galaxies, which consist of gas, dust, clusters of stars called galactic clusters, and many millions of separate stars arranged in two or more flat spiralling arms, the whole being surrounded by a hundred or so globular clusters.

2. *Elliptical Galaxies* accounting for 15% of all galaxies, which consist of the same components but arranged in an ellipsoidal shape.

3. *Irregular Galaxies*, accounting for 5% of all galaxies, which have no consistent shape, for example the Magellanic Clouds.

There were 35 members and visitors present.

December 8, 1955—The meeting was called to order by the President, Mr. Page, at 8:05 after dinner of turkey and baked-Alaska, in the banquet room of the Corona Hotel. He thanked the executive members and the social committee for their work during the year, and introduced Mr. and Mrs. Creese, members of an Astronomical Society in Oakland, California, who were visiting in Edmonton.

Reports were given by the University Observatory Committee, the Observers' Group, Treasurer, Secretary and Nominating Committee. The new slate was elected.

The main address was given by Dr. H. B. Collier, Professor of Biochemistry, on

the History and Development of Science in China. The Chinese have the longest continuous record of any civilization, 3000 years. A series of volumes by Needham interpreting these records will be both complete and important.

Qualities of Yin and Yong, light and dark, started a classification which later included five elements, water, wood, earth, fire, air. Still later these were all mixed in superstition.

There is good reason to suggest our modern chemistry originated in China—as alchemy, the usual search for gold and the elixir of life. The chemistry of mercury was fascinating as also was that of lead, an opposite.

Lodestones and magnetic needles were known in China, but the famous South-pointing carriage has turned out to be mechanical.

Substantial connection of tides with the moon was inferred and also the lunar calendar. It was known that the year is not exactly 365¼ days, and adjustments were made occasionally by skipping a lunar month.

Kubla Khan had two observatories established, on Mongol and on Chinese. Reproductions of the original equatorial instruments are now in Pekin. There exists a star map from the second century B.C., which is on copper, and arrived in Japan through Korea.

The Chinese gentleman's aversion to working with the hands contributed to the decline of science. There is now an emphasis on work as we know it, and Russian translations are emphasized. The party line may injure Chinese science today, since even medical treatment is dependent on the patient's politics. However we must not under-rate the effort the Chinese people can make.

The new president, Dr. Crosby, took the chair, and thanked the meeting.

There were 47 members and visitors present.

E. H. Gowan, *Secretary*.

AT OTTAWA

January 13, 1955—The regular monthly meeting of the Ottawa Centre was held in the National Museum Lecture Hall. The President, Dr. J. L. Locke, introduced the speaker of the evening, Dr. C. S. Beals, the Dominion Astronomer.

Dr. Beals had been asked to give an introductory survey of the field of astronomy and he chose as his title, "Understanding the Universe". Before starting his lecture he explained that the aim of pure science is an attempt to comprehend the universe in which we live.

The first part of his talk consisted of a brief description of the planets. The earth itself is made up of the crust, the solid mantel, the liquid core and the solid inner core. From the overall density of the earth it has been found that the core is much denser than the surface material; however, it is not necessary to assume that the core is composed of iron, as much of the increase in density of the earth toward its centre could be caused by the increasing compression. The terrestrial planets, Mercury, Venus, the earth, Mars and Pluto, are believed to be rocky and more or less homogeneous. As a visual object the most striking feature of Venus is its phases, full, quarter and new. Although there is some indication of vegetable life on Mars, it is rather cold for human life. The canals are generally regarded as natural features, not man-made. The major planets, Jupiter, Saturn, Uranus and Neptune, probably have rocky cores, but they consist mostly of solidified gases, ammonia, methane, hydrogen

and helium. The spectacular bands of Jupiter are parallel to the planet's equator and appear to be atmospheric currents produced by its rapid rotation.

In connection with the origin of the solar system, Dr. Beals showed how the old nebular hypothesis of Kant and Laplace gave way to the new nebular hypothesis of Weiszacher and Kuiper. Before a hypothesis can be accepted it should conform as closely as possible to accepted physical principles. Two principles which have caused much difficulty are: (1) the tendency of gases to disperse and (2) the constant quantity of the angular momentum in an isolated system.

Outside our solar system lie the countless stars which form our galaxy. From a study of their spectra we find that the stars consist mainly of hydrogen and helium, and hence it is believed that the source of stellar energy is the transformation of hydrogen into helium in the interior of the stars. Dr. Beals went on to explain that the space between these stars is not empty, but is filled with gases and small particles referred to as interstellar material. This material gives rise to absorption lines which are sometimes double or even multiple.

From our point of view within the galactic system the most striking feature is the Milky Way. Its appearance suggests that the system is much flattened and that the sun is not at its centre. The generally accepted belief is that the galaxy has a spiral form similar to that of the many spiral nebulae. These nebulae are known to be extra-galactic systems, and from a study of their spectra we find that they are moving away from us. This result leads to the belief that the universe is expanding. Many men have put forth theories to explain this phenomenon; Dr. Beals emphasized, however, that while these theories should be welcomed, they should not be accepted uncritically.

Before closing Dr. Beals mentioned the relatively new field of radio astronomy. In 1931 radio waves from outer space were first observed by Jansky. Since then the sun, our galaxy and even the external galaxies have been studied by means of radio waves.

The lecture was illustrated with an interesting collection of slides. Dr. P. M. Millman expressed the hearty thanks of an appreciative audience to Dr. Beals for a very enlightening and enjoyable talk. At the close of the meeting Dr. Locke announced that further meetings would be held in the new Geophysical Laboratory of the Dominion Observatory.

February 10, 1955—The meeting was held in the Library-Assembly Hall of the Observatory's new Geophysical Laboratory, with the President, Dr. J. L. Locke in the chair. Dr. Locke first thanked Dr. Beals and the Observatory for making the hall available for the meetings of the Ottawa Centre. He then introduced the speaker, Dr. L. Voyvodic of the National Research Council.

Dr. Voyvodic chose as his topic "Properties of Cosmic Radiation". Cosmic rays can be divided into two components. Those with low energy decay very quickly, giving rise to positive and negative electrons, and are known as the soft component; the more penetrating particles, the great bulk of which are mesons, form the so-called hard component. Since these particles are affected by the earth's magnetic field they must be electrically charged.

Investigation has shown that the primary cosmic rays consist of extremely energetic atomic nuclei, mostly protons and alpha particles. This primary radiation reacts with the atmosphere producing mesons, which in turn degenerate into gamma rays. Also

it has been found that there is not only one meson, but a whole family of them. In the field of cosmic rays there are at the moment two lines of activity: the study of the primary radiation, and the use of mesons to study high energy nuclear phenomena.

With the aid of slides, Dr. Voyvodic proceeded to describe the investigation of primary cosmic radiation. High-altitude balloons, carrying nuclear photographic plates, travel thousands of feet above sea-level. These plates, viewed under a high-power microscope, show the tracks of different cosmic particles. From a study of the tracks, it is possible to deduce the energy and velocity of the particles, and from these the mass can be calculated with an accuracy of a few per cent. From a study of fluctuations in the energy of cosmic rays at sea-level, the National Research Council has shown that there is an absence of low energy radiation in the primary cosmic rays. Hence it is believed that either the magnetic field of the sun may deflect the low energy particles, or the source itself does not produce them. Of those with sufficient energy to bombard the earth, the particles with lower energy are deflected from their path by the magnetic field of the earth and never reach the earth's atmosphere above the equator. Thus, as one would expect, it is found that the energies of cosmic rays vary with latitude, showing a definite leveling off at the poles.

Before closing Dr. Voyvodic discussed the various theories of the origin of cosmic rays, the more popular of which have to do with the electromagnetic acceleration of the particles. Each theory predicts a definite maximum energy for cosmic rays. These particles have been found to have energies up to a hundred million electron volts—but is there a maximum? To answer this question it is necessary to examine the most penetration mesons, which have been found as far underground as 6000 feet below the earth's surface. From a study of these it may be possible to obtain, not only the maximum energy, but also the age of cosmic rays.

A short question period followed the lecture, after which Mr. M. M. Thomson thanked Dr. Voyvodic for a very interesting and informative lecture in the new field of cosmic rays.

March 15, 1955—The meeting was held in the Geophysical Laboratory of the Dominion Observatory with the President, Dr. J. L. Locke, in the chair.

The speaker of the evening, Mr. N. W. Broten of the Solar Noise Section of the National Research Council, was introduced by Dr. Locke. As his subject Mr. Broten chose "Exploring the Universe by Radio". After a brief description of the ionized layers of the earth's atmosphere, known as the E, F_1 and F_2 layers, he outlined, with the aid of slides, the different types of radio telescopes or antennae in the world today. These telescopes are used to study a large variety of objects including meteors, the sun, stars and peculiar objects in our galaxy and even other galaxies and colliding galaxies.

In building a radio telescope, Mr. Broten explained that one of the chief difficulties arises from the fact that radio waves are comparatively long waves. This means that in order to obtain a sufficiently high resolving power it is necessary for the telescope to have a very large aperture. To increase the size of the aperture scientists have built linear arrays of collectors.

The speaker went on to explain that radio sources have been discovered which have not been seen with the optical telescope until very recently. Several of these

radio sources such as that in Cygnus are believed to be colliding galaxies, while others such as the Crab nebula are thought to be the remains of explosions of super novae. By means of the radio telescope we can examine objects which cannot be studied by any other means, and thus probe further into the mysteries of the universe.

Dr. Ian Halliday thanked Mr. Broten for his excellent description of the rapidly advancing field of Radio Astronomy.

May 9, 1955—The meeting was held in the Lecture Hall of the National Museum with the President, Dr. J. L. Locke, in the chair. As our speaker we were privileged to have Sir Harold Spencer Jones, F.R.S., the Astronomer Royal, who spoke on the subject "The Expanding Universe".

Some members of our audience had only the vaguest idea of the mysteries of the universe, while others had been working in the field of astronomy or related sciences for most of their lives—but whether amateur or professional, everyone was intrigued with the fascinating way in which Sir Harold discussed the development of one of the oldest sciences. His excellent selection of slides portrayed our own planet, earth, the other members of the solar system, the stars, our galaxy—the most prominent feature of which is the Milky Way—and the many beautiful spiral nebulae. Einstein has shown that a static universe could not exist, as it would be unstable. This theory, combined with the fact that the greater the distance of a galaxy from the earth, the faster it is moving away from us, first gave rise to the idea of an expanding universe.

Sir Harold then put forth two theories of the origin of the universe. The first theory is based on the idea of a single creation with the energy of the universe gradually dissipating as the universe expands. In contrast to this, the second theory assumes a continuous creation with new galaxies forming as the old ones pass beyond the observational horizon. After discussing these theories, Sir Harold emphasized that all theories must be tested by observation and that so far no foolproof method has been found for finding the age of the various galaxies.

Dr. C. S. Beals, the Dominion Astronomer, thanked Sir Harold for an interesting synthesis of the science of astronomy.

October 18, 1955—The meeting was held in the Geophysical Laboratory of the Dominion Observatory with the President, Dr. J. L. Locke, in the chair. Dr. Locke introduced the speaker, Dr. A. E. Douglas of the National Research Council. For his illustrated lecture Dr. Douglas chose the title, "Comets".

Since earliest times bright comets have been objects of interest to all because of their spectacular nature. From a study of their orbits it is now believed that all comets are members of the solar system. The mass of these unusual objects is very small—probably less than one millionth of the mass of the earth. This fact has been deduced from the observation that the orbits of planets are unaffected by the close approach of comets. Like other members of the solar system, comets are not self-luminous, but obtain their light from the sun. Part of this is reflected sunlight and the remainder is fluorescence. From a study of this fluorescence, Dr. Douglas showed what conclusions could be drawn concerning the substances found in comets.

Although no bright comets have been observed recently, an average of five new comets appear each year. This number is unusually large when one considers that some comets are lost while others disintegrate. All short term comets will be used up in about one hundred million years, Dr. Douglas explained and hence there must

be a store of comets, or comets are being created. The most popular theory presupposes that a large number of comets were left over when the solar system was formed. While this theory is fairly widely accepted, other scientists believe that comets can be created from dust particles attracted towards the sun from all directions. The problem of finding a satisfactory theory is complicated by the fact that we still have no clear idea of the actual appearance of comets.

In thanking the speaker, Dr. J. A. Rottenberg commented on the clarity with which Dr. Douglas distinguished between what is known about comets and what is pure hypothesis.

November 8, 1955—The meeting was held in the Lecture Hall of the National Museum with the President, Dr. J. L. Locke in the chair.

The main feature of the evening was a colour motion picture of the airborne expedition which successfully photographed the total eclipse of the sun off the east coast of Labrador on June 30, 1954. The film first showed the departure of the party from Rockcliffe Airport and the flight to Goose Bay, Labrador, where the expedition was based. In order to obtain a clear view of this unusual phenomenon it was necessary for the aircraft to climb to 27,500 feet. The main instruments aboard were two spectrographs operated by scientists from the Dominion Observatory and the National Research Council. With these instruments special photographs of the solar spectrum, obtainable only when the sun is totally eclipsed, were taken from a point off the northern Labrador coast. Miss Miriam S. Burland, the only lady scientist aboard, observed the corona during the eclipse and prepared a message for transmission from the aircraft and via the C.B.C. to scientists in Sweden. This message enabled the scientists to make final adjustments to their instruments before the moon's shadow, which sped across the ocean, reached their stations.

This documentary film was prepared by the Royal Canadian Air Force, who cooperated with the Dominion Observatory and the National Research Council to make the eclipse expedition a success. Dr. P. M. Millman, who was in charge of the scientific personnel, introduced the film, which was shown on November 8 for the first time in Ottawa. In addition to the feature film, Dr. Millman showed shots of the various phases of the eclipse, taken from the aircraft by a C.B.C. photographer, and films describing the airborne expedition he directed to observe the 1945 eclipse.

As well as the films the audience viewed some coloured slides of the airborne expedition, introduced by Wing Commander D. A. MacLulich, and some of the Dominion Observatory Ground Expedition taken by Dr. J. L. Locke.

Several of the scientists on the Ground Expedition travelled to their base at Smoky Falls in Northern Ontario at the beginning of June, a month before the expected eclipse. Cement pillars, on which to rest the various scientific instruments, had to be made, and a housing 23 feet long, built at the Dominion Observatory, had to be put up to protect the spectrograph. The slides showed the scientists at work, as well as many of the beauties of the north country. Only one dark spot spoiled the expedition —the scientists spent the morning of June 30 sitting in dense fog.

December 6, 1955—The annual dinner meeting was held in the cafeteria of the Experimental Farm with about 80 members and guests present. After dinner there was a short business meeting at which the new slate was elected for 1956.

Following the election, Mr. A. E. Covington took over the chair and called on the retiring President, Dr. J. L. Locke, to speak on the subject "The Utilization of Solar Energy".

In recent years there has been increasing concern over the world-wide depletion of the accessible fossil fuel reserves, principally of petroleum oil. Before the end of the century the demand for petroleum will considerably exceed the readily accessible supply, and the cost of this fuel will rise. Fossil fuels are essential to our present air and road transport, but over one quarter of the liquid fuel consumed is used for space heating. For this purpose alternative energy sources would serve equally well, and hence it is important that we begin now to investigate these alternatives, one of which is solar energy. In the form of radiation over the surface of the earth we receive the sun's energy in enormous quantities without charge.

Tests indicate that it is feasible to keep a house at uniform temperature throughout the year, day and night, by storing the energy which falls during clear days for use at night or during cloudy periods. Summer heat may even be stored for use during the winter. To illustrate this point Dr. Locke showed designs of model houses in which the heating is accomplished by the capturing of solar radiation.

Other uses of solar energy which appear successful include the distillation of water and cooking of food in remote areas. A "solar battery" has recently been developed which converts solar energy directly in electricity with high efficiency. It is planned to use this converter to power mobile radio equipment and amplifiers on rural telephone lines.

With solar energy it is possible to obtain very high temperatures for research purposes. This method could be used to study the melting point of silicates; it has the advantage over the use of ordinary furnaces, in that the sample can be kept very pure. Temperatures as high as 3000°C. have been obtained by using a parabolic mirror with as large a diameter and as short a focal length as possible. The one disadvantage of this method is that it can be used only when the sun is shining.

Very little work has so far gone into this field of research, but it is likely that in the future solar energy will become more and more widely used to supplement the usual energy sources.

Mr. W. J. Medd thanked Dr. Locke for describing in such an interesting way the many possible uses for the large quantities of energy supplied by the sun.

JOAN STEWART, *Recorder.*

AT MONTREAL

November 22, 1954—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

An interesting ceremony marked the opening of this meeting—the presentation of a projector to Mr. and Mrs. Garneau in recognition of the very great service they rendered to the Centre. At their invitation regular observation meetings were held at Ville Marie Observatory—at their home—from December 6, 1941, to November 23, 1954, a period of 13 years during which their home became also the "Home" of the Centre. Without this most generous contribution, the outstanding work accomplished by the Centre would not have been possible.

The speaker of the evening was Miss Ruth Northcott, of David Dunlap Observatory, whose subject was "Stellar Rainbows". The speaker traced, historically, the analysis of light from Newton's experiments with prisms, through successive generations of scientists—showing what had been, and could be, learned by the interpretation of light from distant bodies by use of the spectroscope and camera.

December 6, 1954—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

The second lecture in the Introductory Series was given by Mr. W. E. Leeson, on "The Planet Mars". Description of the physical elements of the planet as at present known were given. Various conflicting theories to account for colour and surface markings were compared, and the possibilities of the existence of life in any form similar to human were reviewed.

January 10, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

The third lecture in the Introductory Series was given by Miss I. K. Williamson, on "The Planet Venus". The reasons for uncertainties concerning surface markings, rotation, etc., were given, and the probable state arising from the composition of the planet's atmosphere and temperature range was described. Although apparently too hot for plant life, the theory that the planet is in a stage similar to the earth's carboniferous period was cited. The phenomena of transits, and the reasons for the interest shown by earlier observers were explained.

January 24, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

"What are these Flying Saucers" was the title of the lecture given by Dr. D. H. Menzel, Director of Harvard College Observatory. Dr. Menzel reviewed history to show that these objects have been known and described by writers for several hundreds of years, citing as an interesting reference "Meteorological and Political Philosophy" written by Reinzer, published in 1709. Flying Saucers are of various kinds, but most of them are reflections from or of natural objects, amongst which have been found: Milkweed seeds; spider webs carried in the air; bats and owls covered with certain luminous fungi; ice crystals, which produce "sun dogs"; optical mirage, reflections caused by layers of cold air with a layer of hot air just above them.

No objects from interplanetary space have been found, nor is there any reason to believe that such exist.

February 7, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

The fourth lecture in the Introductory Series was given by Mr. Brian Cockhill, his subject being "The Moon". The moon was compared with other satellites, and brief accounts of several theories of its origin was given. Because of its nearness, the moon has been very closely studied, and the speaker summed up the known facts. Diversities of opinion among astronomers concerning the origin of lunar "scenery" were shown to exist, and that no theory yet advanced could be considered final.

February 21, 1955—The meeting was held at the Macdonald Physics Building, McGill University, the chairman being the president, Mr. Charles M. Good. The lecture was given by Dr. Allen C. McNamara of the National Research Council, on the subject "The Aurora and Radar Studies of the Upper Atmosphere".

Comparing graphs of auroral frequency with the sun-spot curve shows that the patterns are not exactly similar. However, there is a correlation between sun-spots, solar flares and terrestrial phenomena. Solar flares eject positively- and negatively-

charged particles which may escape from the sun and after an interval of 26 hours may reach the earth (having travelled at a velocity of 600 km./sec.). The observed effects in the upper atmosphere cannot be readily explained.

The visible aurora is a result of recombinations of high-speed ionized particles. The characteristic green colour is due to oxygen atoms, and the red to nitrogen atoms or possibly oxygen atoms. The auroral streamers appear to follow the lines of force of the earth's magnetic field; the corona form appears when the observer is immediately below the display.

Radar reflections from aurorae have been studied. However, not all aurorae produce radar reflections. Echoes are produced only when the aurora is not more than 20° from the horizon; intense aurora overhead will produce no effect on radar. Possible reasons for this were discussed. Meteors entering the upper atmosphere also cause ionization and radar reflections from this cause have been studied.

The International Geophysical Year from 1957 to 1958 will be during a period of maximum solar activity. It is hoped that the intensive work at this time will lead to tests of theories of the aurora and other upper atmosphere phenomena.

March 7, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

The fifth lecture in the Introductory Series was given by the Recording Secretary, Mr. E. E. Bridgen, whose subject was "The Planet Saturn".

March 21, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the vice-president, Mr. H. F. Hall. The speaker was Prof. C. Fox of McGill University, who lectured on "Astronomical Speculations through the Centuries". The earliest records show that a considerable body of knowledge then existed, and that deep interest had been taken by the ancients. In fact, more than 200 years B.C. the radius of the earth was determined at a figure not greatly differing from that now accepted. The speaker traced the considerations which led from observational material to workable theories by Kepler, Newton, Einstein, Milne and others. A most interesting question period followed the lecture.

April 4, 1955—The meeting was held at Macdonald Physics Building, McGill University, the chairman being the president, Mr. Chas. M. Good.

The final lecture in the Introductory Series was given by the president, Mr. Chas. M. Good, on "The Planet Jupiter". The elements of the planet were reviewed and the distinction drawn between the terrestrial and major planets. The most massive of all the planets, Jupiter, exercises a considerable influence on movements within the solar system, and controls the movements of about 30 short-period comets.

April 18, 1955—The meeting was held at the Montreal High School, University Street, under the direction of the president, Mr. Chas. M. Good. The feature of the meeting was the visit to the Planetarium, in which demonstrations were given by Miss Miller, of the School staff. As it was necessary to divide the audience into two groups, slides and films were shown of the activities of the Centre to one group whilst the other witnessed the demonstration.

May 9, 1955—The meeting was held at Macdonald Physics Building, McGill

University, the chairman being the president, Mr. Chas. M. Good. This was the closing meeting of the season. The president referred to the difficulties experienced in obtaining films on astronomical subjects in explaining the colour film afterward presented—"The Four Seasons". Mr. J. Duffie gave a short talk, "Astronomy on Stamps", and exhibited a number of specimens. As is the custom of the Centre, a social session followed, during which refreshments were served by the Ladies Committee.

EDWIN E. BRIDGEN, *Recorder*.

AT TORONTO

May 7, 1955—The meeting was held in Convocation Hall, University of Toronto. Members of The Royal Canadian Institute and The Meteorological Society joined with the R.A.S.C. in this special meeting. The President, Mr. L. H. Clark was chairman.

Dr. J. F. Heard introduced the speaker Sir Harold Spencer Jones, the Astronomer Royal. Sir Harold's subject was, "Life on Other Worlds".

Life as we know it can exist only if temperature, amounts of oxygen and moisture present on earth fall within very narrow limits, this environment is largely dependent on the earth's distance from the sun and its mass.

A survey of the sun's family of planets reveals that the giant planets, because of their great mass, have retained much of their original atmospheres, whereas the small-mass terrestrial-type planets have lost virtually all of their original atmospheres. The outer planets because of their great distances from the sun are too cold to support life and Mercury because of its closeness to the sun, too hot. The possible abodes for life, other than the earth, are Venus and Mars.

Venus slightly smaller than the earth, and closer to the sun, has an atmosphere which shows no oxygen but an abundance of carbon dioxide indicating little if any plant life. Because of the "greenhouse" effect of carbon dioxide in the atmosphere, the surface temperature of Venus must be high. Venus is pictured as a dry sterile world, plagued by great storms and cyclones which hurl dust high into the atmosphere thus obscuring its surface.

Mars, because of its small mass, retains only a very tenuous atmosphere. The polar caps can not be much more than a fraction of an inch thick because of the rapidity with which they disappear with seasonal advances. Colour changes of the dark regions could be due to a low order of plant life similar to terrestrial mosses and lichens which can survive under extreme conditions. The surface temperature of Mars reaches about 50°F. at noon in the summer time but becomes extremely cold at night. Supposed geometrical markings on Mars probably have no real existence, as such, being a myriad of fine detail viewed at the limit of resolution and under average seeing conditions.

Life came into existence on earth where the mass, distance from the sun, presence of moisture, and other suitable elements provided a suitable environment. If another planet presents conditions similar to that of the earth, it is likely that life will come into existence there. Mass and distance from the sun would not always be a reliable guide as witnessed by the case of Venus.

Modern theories of star formation support the view that planetary bodies are born of the same processes and out of the same clouds of gas and dust as the stars themselves, it is therefore reasonable to suppose that the great majority of stars may have

planets associated with them. Scattered throughout these planetary systems there is likely to be some planets with conditions suitable for supporting life. The picture is complicated by the fact that the greater proportion of stars are multiple systems with the resulting complex orbital patterns.

Life can be regarded as rare, but nevertheless occurring here and there throughout the universe of billions of stars and millions of galaxies.

Mr. Tracey Lloyd, President of The Royal Canadian Institute, thanked the speaker.

RAYMOND R. BROADFOOT, *Recorder.*

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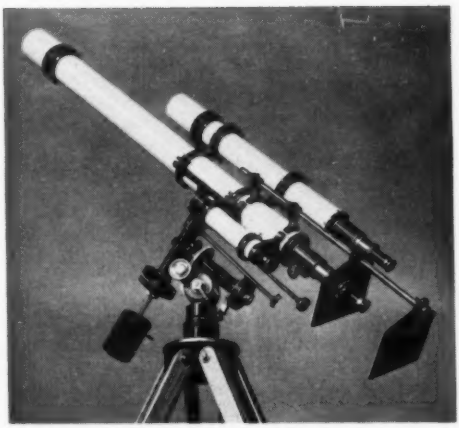

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